An Overview of Marine Environmental Research Pertaining to West Coast Offshore Oil and Gas Development

D. Bancroft[1], R. A. Lake[2], S-L. Marshall[3] and K. Lee[4]

Proceedings of a Workshop at: Institute of Ocean Sciences, Fisheries and Oceans Canada, 9860 West Saanich Road, Sidney, British Columbia, V8L 4B2, Canada. January 8-10, 2003.

Sponsored by: Program of Energy Research and Development (PERD), Natural Resources Canada (NRCan) and Centre for Offshore Oil and Gas Environmental Research (COOGER), Fisheries and Oceans Canada (DFO)

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An Overview of Marine Environmental Research Pertaining to West Coast Offshore Oil and Gas Development

by

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ABSTRACT

This report provides an overview of a workshop hosted by the Program of Energy Research and Development (PERD), Natural Resources Canada and the Centre for Offshore Oil and Gas Environmental Research (COOGER), Fisheries and Oceans Canada to provide information on the state of scientific knowledge that is of relevance to the possible lifting of the West Coast Moratorium on offshore oil and gas activity. The research of various scientists is presented in this report including overviews of relevant PERD research, the activities of COOGER, the National Working Group on Oil and Gas, and the National Geoscience for Ocean Management Program. The report examines the current relevance of previous West Coast research studies and the applicability of research deliverables from recent East Coast studies. Priority research areas, together with potential costs, time lines and partnerships, are identified.

RESUME

Le présent rapport rend compte d'un atelier tenu par Ressources naturelles Canada, dans le cadre du Programme de recherche et de développement énergétiques (PRDE), ainsi que par le Centre de recherche environnementale sur le pétrole et le gaz extracôtiers (CREPGE) de Pêches et Océans Canada. Cet atelier avait pour objet de fournir des renseignements sur l'état des connaissances scientifiques pertinentes en vue d'une éventuelle levée du moratoire sur les activités pétrolières et gazières au large de la côte ouest. Le rapport fait état des résultats des travaux de divers scientifiques, en présentant notamment un aperçu des recherches pertinentes effectuées dans le cadre du PRDE, ainsi que des activités du CREPGE, du groupe de travail national sur le pétrole et le gaz et du programme national de géosciences pour la gestion de l'océan. On y examine également la pertinence des recherches antérieures effectuées sur la côte ouest et la possibilité d'appliquer à cette dernière les résultats des recherches effectuées sur la côte est. Enfin, on y définit les priorités en matière de recherches, les coûts et délais connexes et les partenariats possibles.

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Objectives

The purpose of the workshop was to provide an overview of scientific information to the Program of Energy Research and Development (PERD) to assist in its development of future research programs to address environmental issues related to the development of offshore oil and gas activity on the West Coast. The workshop goals were:

- to provide overviews of relevant research activities in PERD, the Centre for Offshore Oil and Gas Environmental Research, the National Working Group on Oil and Gas (DFO) and the National Geoscience for Ocean Management Program (NRCan);
- to identify relevant research from previous West Coast studies;
- to determine what from the more recent East Coast work is applicable to the West Coast; and
- to be cognisant of relevant research activities by the academic sector and the oil and gas industry, and other government agencies within British Columbia.

The workshop objectives were achieved through a series of presentations followed by three focused working groups that provided recommendations to PERD.

Participation

Those attending the workshop included: senior science advisors from DFO and NRCan; leaders from the Centre for Offshore Oil and Gas Environmental Research, the National Working Group on Oil and Gas and the National Geoscience for Ocean Management Program; leaders from relevant PERD Programs at the Objective Level (POLs); DFO scientists with expertise in physical, chemical and biological oceanography, including fisheries; NRCan scientists with expertise in marine geology and earthquakes; Environment Canada (EC) scientists with expertise in meteorology, marine emergencies, environmental toxicity and pelagic birds; a National Research Council (NRC) scientist with expertise in marine safety; Parks Canada scientists with expertise in marine ecology; a university research manager; and an environmental specialist from the oil and gas industry. A complete list of those participating in the workshop is attached (Appendix A).

Background

Continental shelves contain a significant portion of the world's oil and gas reserves. The Geological Survey of Canada estimates the sedimentary basins in the continental shelf area adjacent to British Columbia hold reserves in the order of 9.8 billion barrels of oil and 43.4 TCF of gas, (Hannigan et al., 2001; Figure 1). The first exploration occurred in 1949 in the Queen Charlotte Island region. In 1967, Shell Canada began a drilling program off Barkley Sound, Vancouver Island. In the next two years, 14 wells were drilled in the offshore in the region from Barkley Sound north through Queen Charlotte Sound and Hecate Strait. Non-commercial levels of oil were found off the Queen Charlotte Islands and some gas was found off Tofino.

The jurisdictions of the Province of British Columbia and the Government of Canada in the area have been addressed in a number of court decisions. In 1967, the Supreme Court of Canada decided that the Territorial Seas off British Columbia, outside of bays, harbours and inland waters, belonged to Canada. In 1972, Canada made a policy decision to not approve any new exploration permits or programs in the West Coast offshore and to suspend all work obligations under existing permits (i.e., a federal moratorium). In 1976, the British Columbia Court of Appeal determined that the Strait of Georgia belonged to British Columbia, a decision upheld by the Supreme Court of Canada in 1984. In the period of 1986 to 1989, British Columbia and Canada conducted negotiations on management and jurisdiction of offshore oil and gas exploration and development, resulting in the Pacific Accord.

The potential impact of offshore oil and gas activity on the environment has been an area of concern. During the period of 1966-1969, Canada withheld exploration approval in the Strait of Georgia until a federal-private study on the effects of seismic exploration on fish stocks was completed. A number of oil spills off the west coast of the continent have increased public concern for the possibility of disasters. In 1969, an offshore rig experienced a blow-out. In the same year, the U.S. made a proposal to transport Alaskan oil south by tanker through British Columbia coastal waters and the Strait of Juan de Fuca. In 1971, the British Columbia legislature passed a resolution opposing tanker traffic off the West Coast. During the period of 1984-1986, an independent federal-provincial environment review panel was established to assess potential environmental and socio-economic effects of offshore oil and gas exploration. The final report recommended that exploration could proceed if 92 specific recommendations were met. In 1989, an oil spill from the barge *Nestucca* off Washington State moved onshore along the West Coast of Vancouver Island. In the same year, the *Exxon Valdez* oil tanker spill occurred in Alaska. This was followed by a decision of the Province of British Columbia that no offshore drilling would occur for at least five years (i.e., a provincial moratorium). Canada announced that it would not consider any development in the offshore until requested to do so by the Province of British Columbia. In 2001, British Columbia appointed an independent scientific panel to examine whether offshore oil and gas could be extracted in a scientifically sound and environmentally responsible manner. The scientific panel concluded, "there is no inherent or fundamental inadequacy of the science or technology, properly applied in an appropriate regulatory framework, to justify a blanket moratorium on offshore oil and gas activities." In the same year, an Offshore Oil and Gas Task Force visited nine northern coastal communities to listen to the views of local residents and aboriginal groups. The task force concluded that northern communities, including

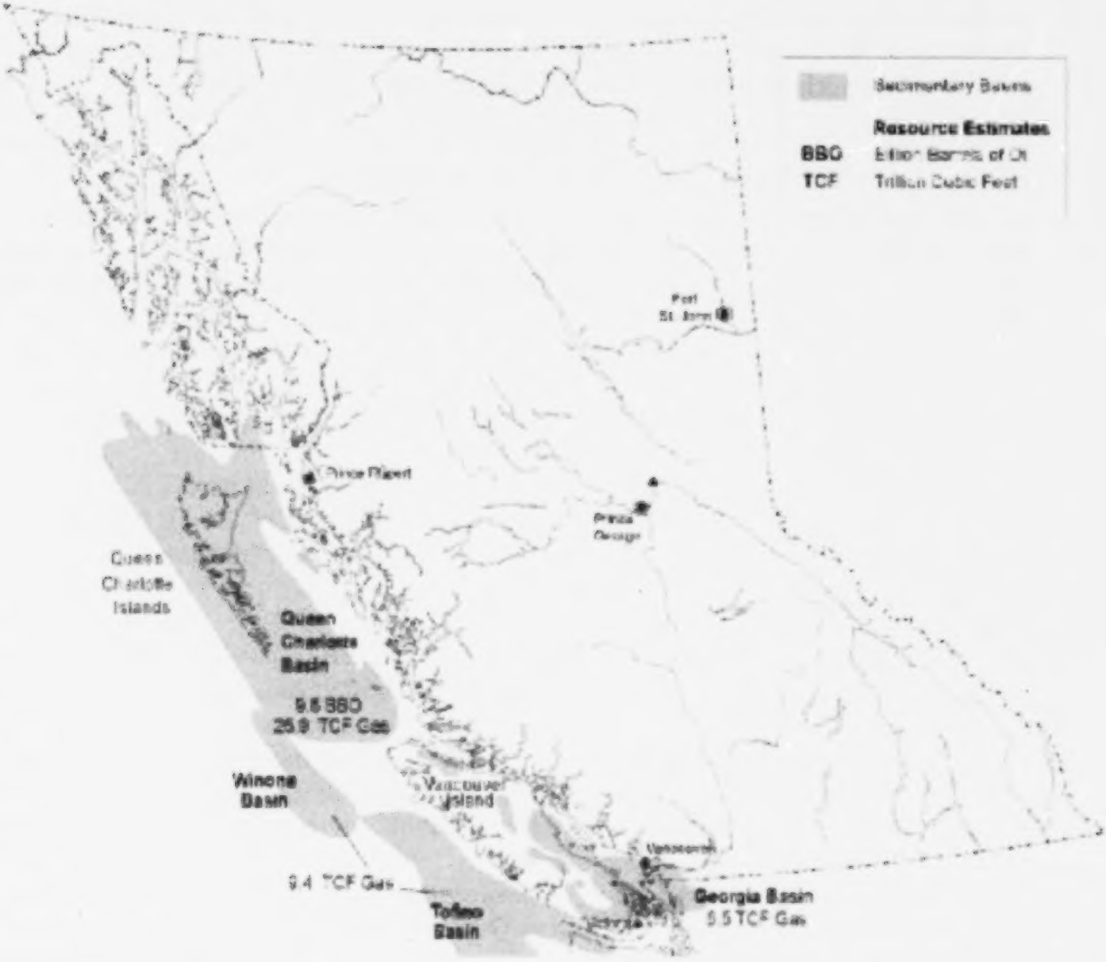

Figure 1. Offshore oil and gas potential in British Columbia. Geological Survey of Canada, unpublished. P. Hannigan, P.J. Lee, K. Osadetz et al., 1993-1998.

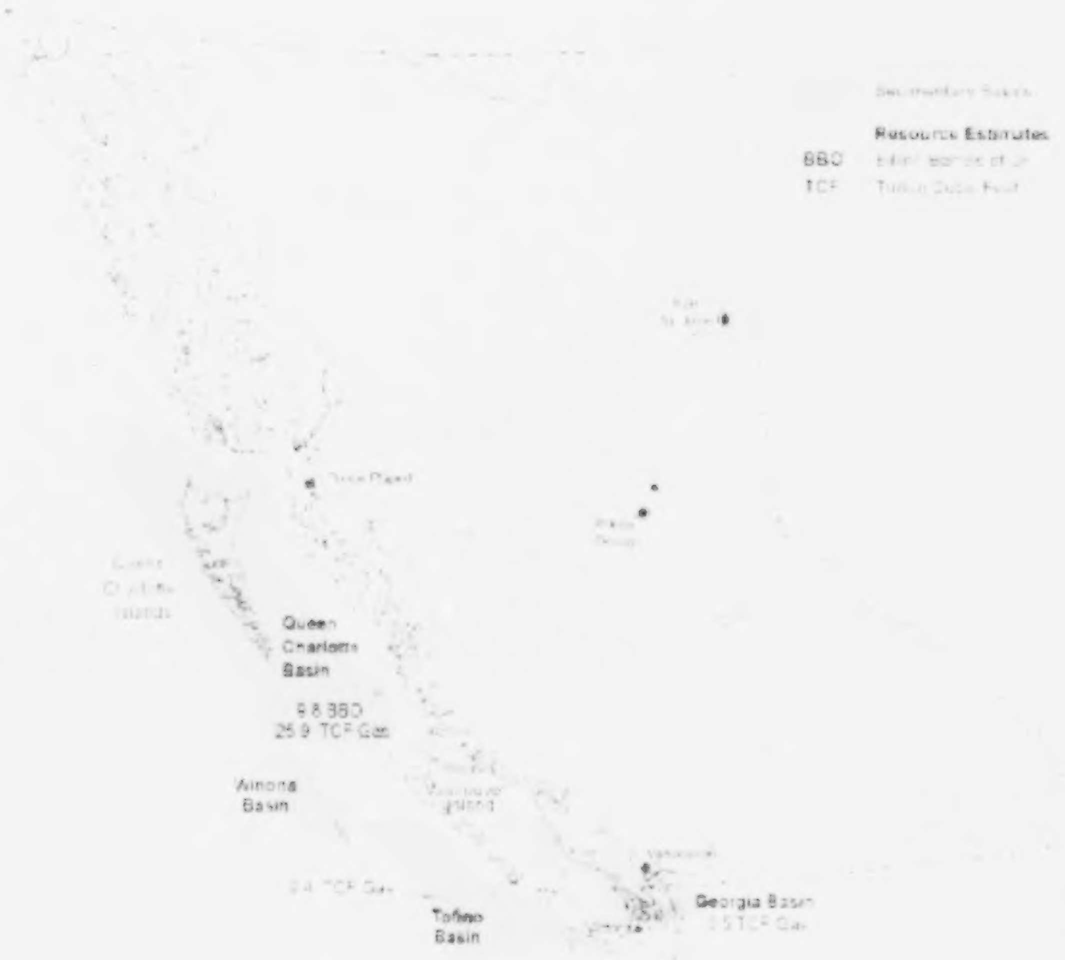

Figure 1. Offshore oil and gas potential in British Columbia. Geological Survey of Canada, unpublished. P. Hannigan, P.J. Lee, K. Osadetz et al., 1993-1998.

aboriginal groups, wanted to have a strong voice in the contemplation of offshore oil and gas. In 2002, the panel and task force made a number of recommendations for further work that needs to be done before any activity begins. In response, the Province of British Columbia enlisted the University of Northern British Columbia (UNBC) to carry out scientific and technical research and develop a work plan that responds to these recommendations.

Reference

P.K. Hannigan, J.R. Dietrich, P.J. Lee and K.G. Osadetz. 2001. "Petroleum resource potential of sedimentary basins on the Pacific Margin of Canada." Geological Survey of Canada. Bulletin 564.

Presentations with corresponding discussions

Workshop outline and ongoing research program overviews

Title	Presenter	Organization	Page
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Title	Presenter	Organization	Page
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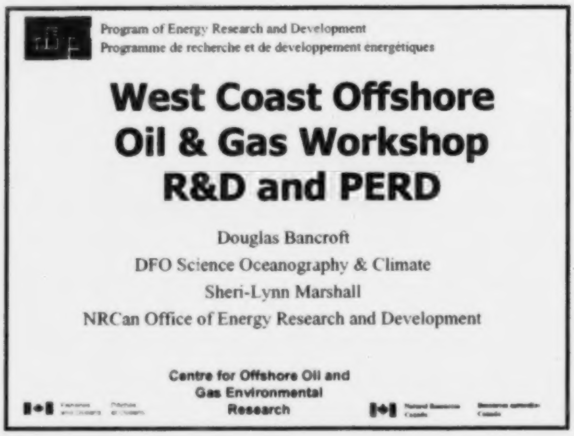
*Editors' note: The discussions following each presentation are transcribed from a recording of the proceedings. In some cases, the text was edited to improve coherence, and reviewed by some presenters to ensure technical correctness. A small portion of the discussion was lost due to background noise and/or technical errors associated with the recordings. Also, some of the slide and image quality is limited. Please contact the appropriate authors if you would like a higher quality version of their presentation.

West Coast Offshore Oil & Gas Workshop R&D and PERD

Introduction and Purpose of the Workshop

D. Bancroft

Fisheries and Oceans Canada



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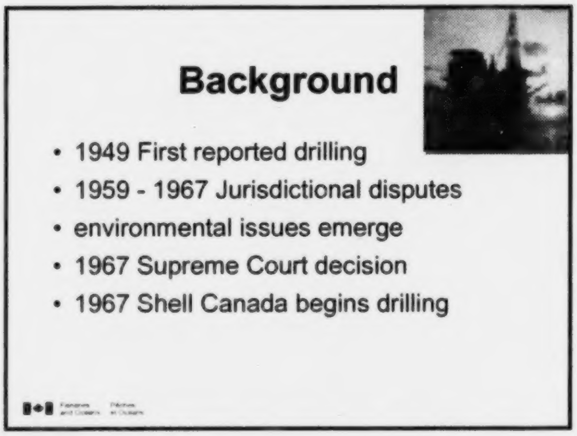
West Coast Offshore Oil & Gas Workshop R&D and PERD

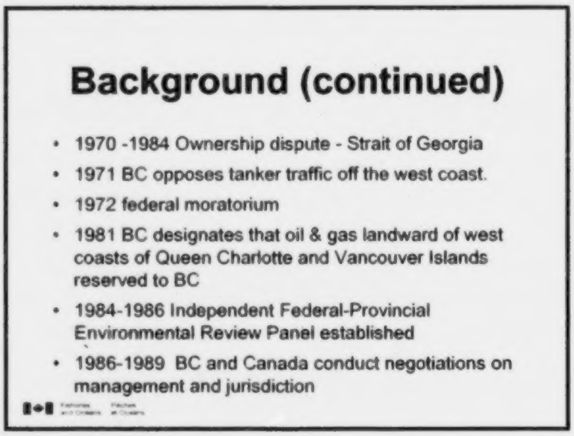
Douglas Bancroft
DFO Science Oceanography & Climate
Sheri-Lynn Marshall
NRCan Office of Energy Research and Development

Centre for Offshore Oil and Gas Environmental Research



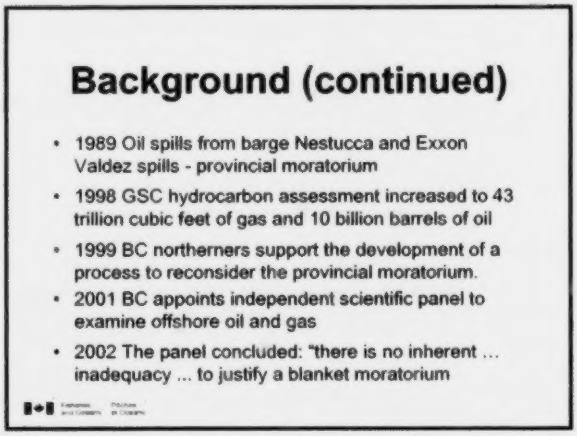
Background

- 1949 First reported drilling
- 1959 - 1967 Jurisdictional disputes
- environmental issues emerge
- 1967 Supreme Court decision
- 1967 Shell Canada begins drilling



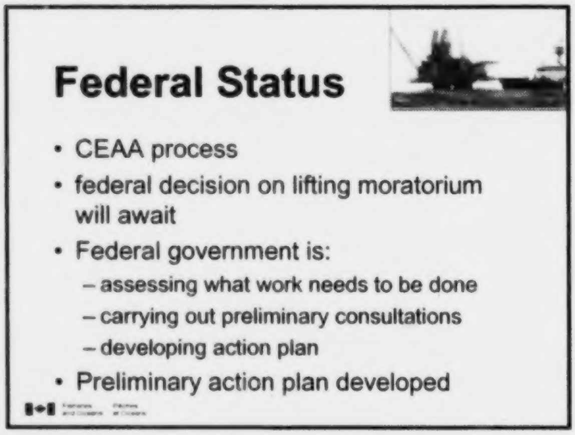
Background (continued)

- 1970 -1984 Ownership dispute - Strait of Georgia
- 1971 BC opposes tanker traffic off the west coast.
- 1972 federal moratorium
- 1981 BC designates that oil & gas landward of west coasts of Queen Charlotte and Vancouver Islands reserved to BC
- 1984-1986 Independent Federal-Provincial Environmental Review Panel established
- 1986-1989 BC and Canada conduct negotiations on management and jurisdiction



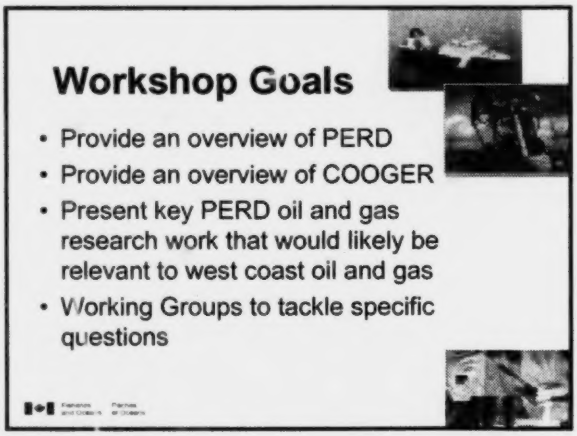
Background (continued)

- 1989 Oil spills from barge Nestucca and Exxon Valdez spills - provincial moratorium
- 1998 GSC hydrocarbon assessment increased to 43 trillion cubic feet of gas and 10 billion barrels of oil
- 1999 BC northerners support the development of a process to reconsider the provincial moratorium.
- 2001 BC appoints independent scientific panel to examine offshore oil and gas
- 2002 The panel concluded: "there is no inherent ... inadequacy ... to justify a blanket moratorium



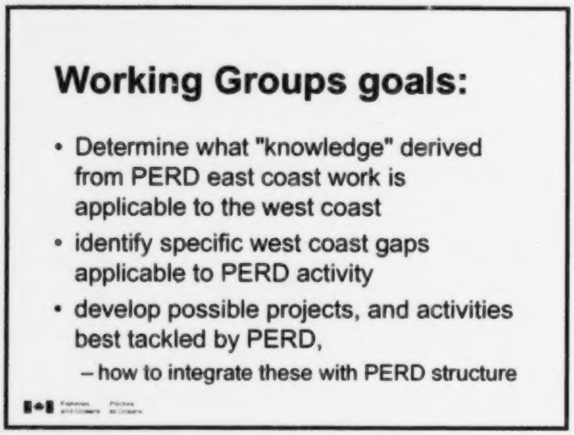
Federal Status

- CEAA process
- federal decision on lifting moratorium will await
- Federal government is:
  - assessing what work needs to be done
  - carrying out preliminary consultations
  - developing action plan
- Preliminary action plan developed



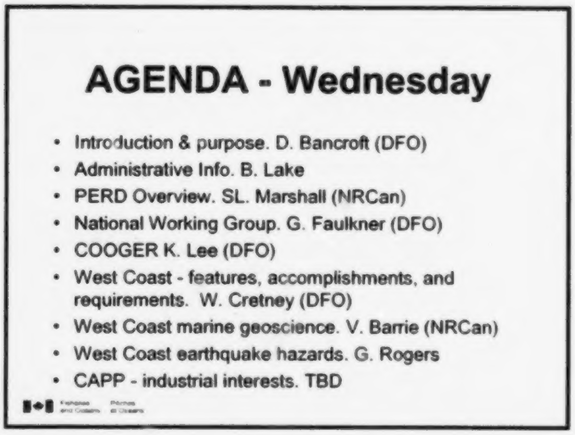
Workshop Goals

- Provide an overview of PERD
- Provide an overview of COOGER
- Present key PERD oil and gas research work that would likely be relevant to west coast oil and gas
- Working Groups to tackle specific questions



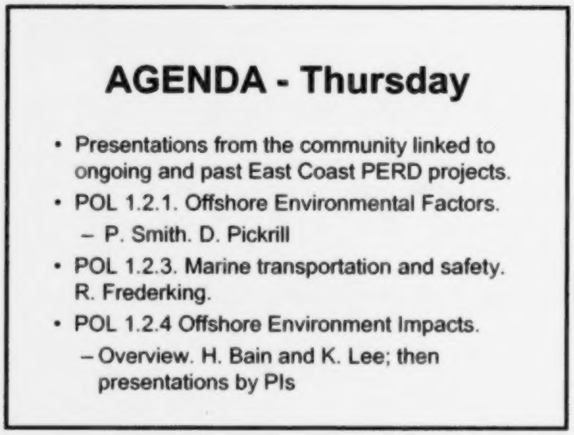
Working Groups goals:

- Determine what "knowledge" derived from PERD east coast work is applicable to the west coast
- identify specific west coast gaps applicable to PERD activity
- develop possible projects, and activities best tackled by PERD,
  - how to integrate these with PERD structure



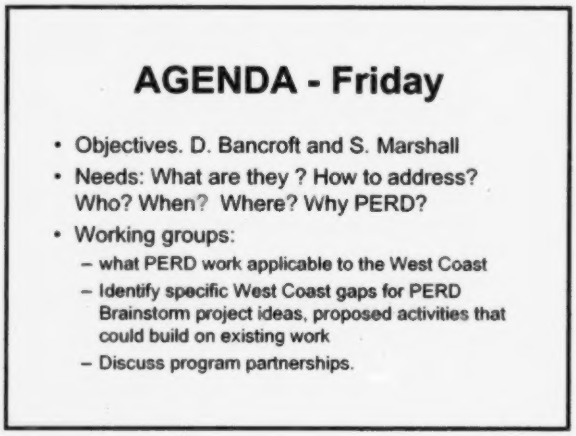
AGENDA - Wednesday

- Introduction & purpose. D. Bancroft (DFO)
- Administrative Info. B. Lake
- PERD Overview. SL. Marshall (NRCan)
- National Working Group. G. Faulkner (DFO)
- COOGER K. Lee (DFO)
- West Coast - features, accomplishments, and requirements. W. Cretney (DFO)
- West Coast marine geoscience. V. Barrie (NRCan)
- West Coast earthquake hazards. G. Rogers
- CAPP - industrial interests. TBD



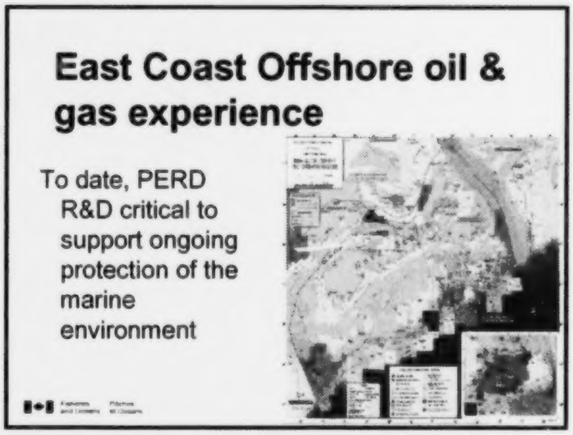
AGENDA - Thursday

- Presentations from the community linked to ongoing and past East Coast PERD projects.
- POL 1.2.1. Offshore Environmental Factors.
  - P. Smith. D. Pickrill
- POL 1.2.3. Marine transportation and safety. R. Frederking.
- POL 1.2.4 Offshore Environment Impacts.
  - Overview. H. Bain and K. Lee; then presentations by PIs



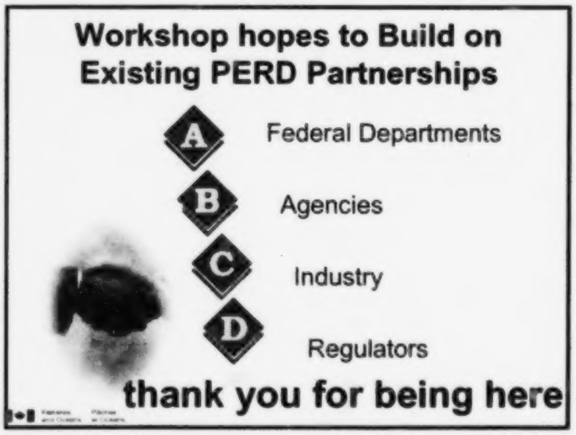
AGENDA - Friday

- Objectives. D. Bancroft and S. Marshall
- Needs: What are they ? How to address? Who? When? Where? Why PERD?
- Working groups:
  - what PERD work applicable to the West Coast
  - Identify specific West Coast gaps for PERD Brainstorm project ideas, proposed activities that could build on existing work
  - Discuss program partnerships.



East Coast Offshore oil & gas experience

To date, PERD R&D critical to support ongoing protection of the marine environment



Workshop hopes to Build on Existing PERD Partnerships

A Federal Departments

B Agencies

C Industry

D Regulators

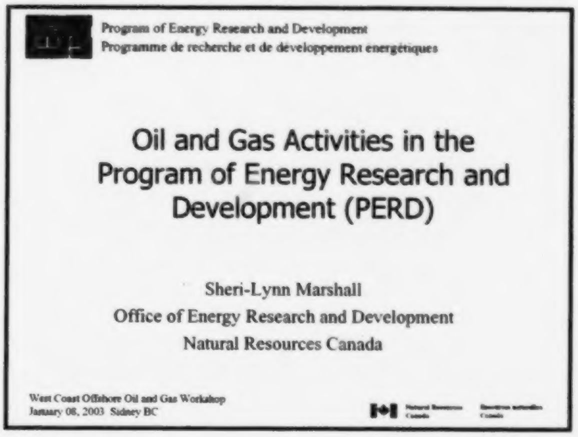
thank you for being here

Oil and Gas Activities in the Program of Energy Research and Development (PERD)

Overview of PERD Emphasis on Offshore Oil & Gas R&D

S-L. Marshall

Natural Resources Canada



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Oil and Gas Activities in the Program of Energy Research and Development (PERD)

Sheri-Lynn Marshall
Office of Energy Research and Development
Natural Resources Canada

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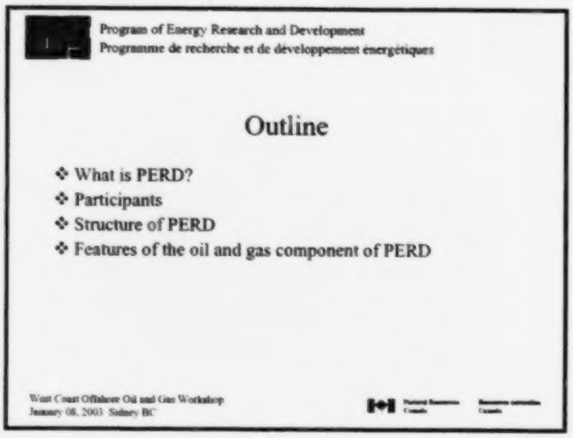

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Outline

- What is PERD?
- Participants
- Structure of PERD
- Features of the oil and gas component of PERD

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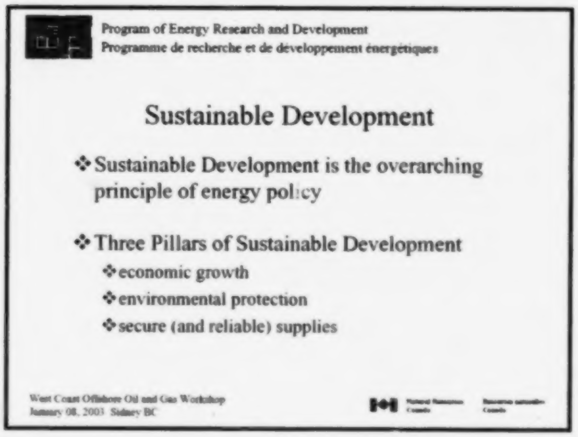

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Sustainable Development

- Sustainable Development is the overarching principle of energy policy
- Three Pillars of Sustainable Development
  - economic growth
  - environmental protection
  - secure (and reliable) supplies

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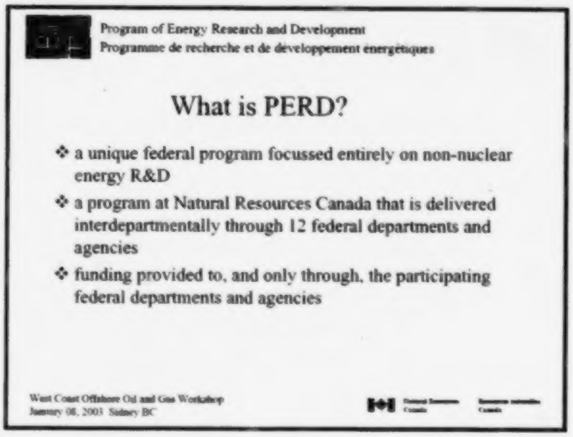

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What is PERD?

- a unique federal program focussed entirely on non-nuclear energy R&D
- a program at Natural Resources Canada that is delivered interdepartmentally through 12 federal departments and agencies
- funding provided to, and only through, the participating federal departments and agencies

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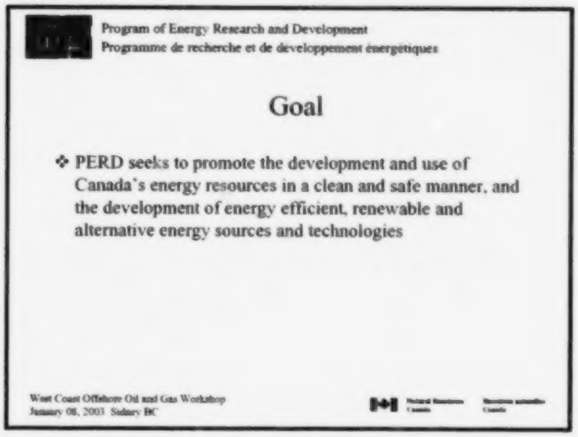

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Goal

- PERD seeks to promote the development and use of Canada's energy resources in a clean and safe manner, and the development of energy efficient, renewable and alternative energy sources and technologies

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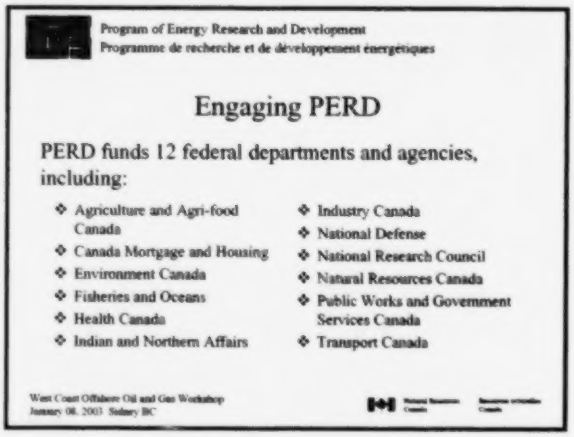

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Engaging PERD

PERD funds 12 federal departments and agencies, including:

- Agriculture and Agri-food Canada
- Canada Mortgage and Housing
- Environment Canada
- Fisheries and Oceans
- Health Canada
- Indian and Northern Affairs
- Industry Canada
- National Defense
- National Research Council
- Natural Resources Canada
- Public Works and Government Services Canada
- Transport Canada

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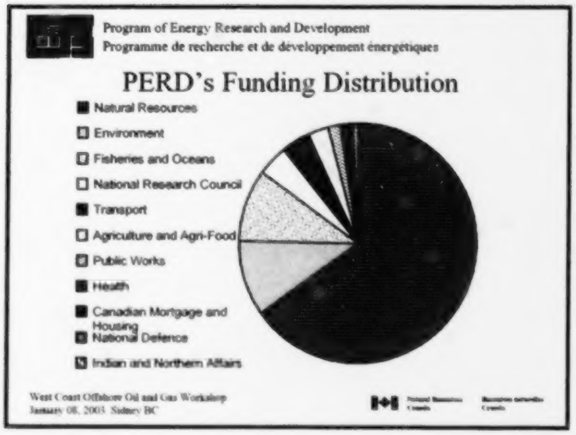

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PERD's Funding Distribution

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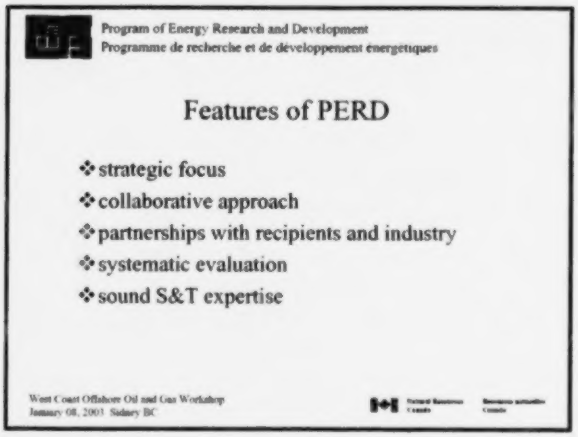

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Features of PERD

- strategic focus
- collaborative approach
- partnerships with recipients and industry
- systematic evaluation
- sound S&T expertise

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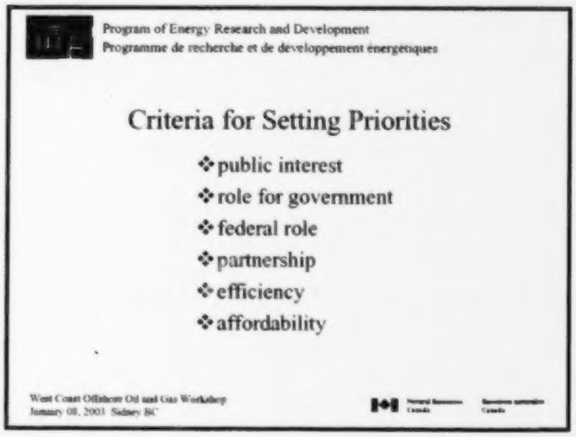

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Criteria for Setting Priorities

- public interest
- role for government
- federal role
- partnership
- efficiency
- affordability

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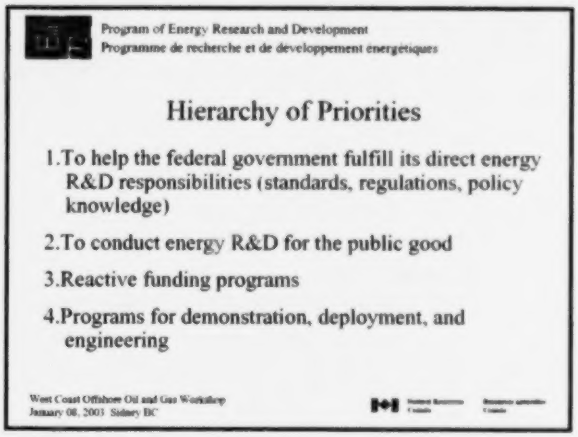
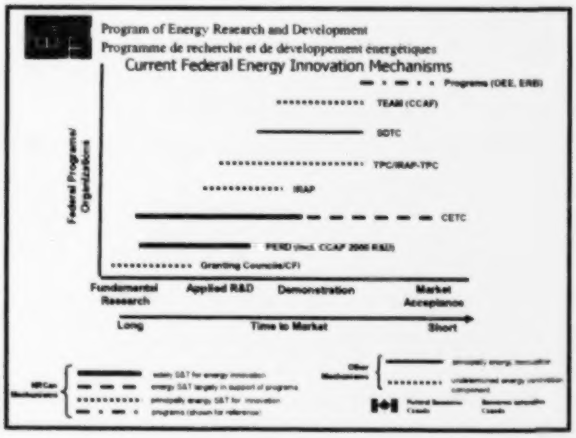


Program of Energy Research and Development
Programme de recherche et de développement énergétiques

Hierarchy of Priorities

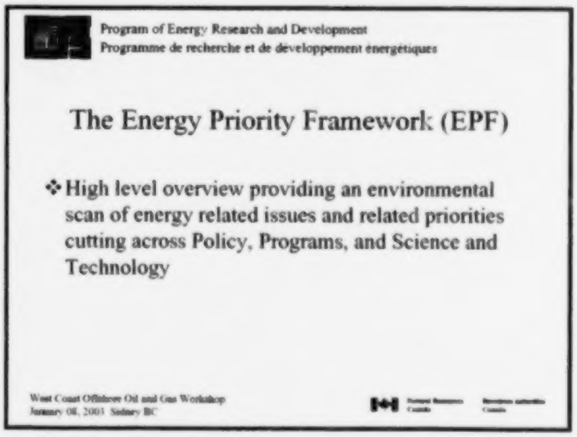
1. To help the federal government fulfill its direct energy R&D responsibilities (standards, regulations, policy knowledge)
2. To conduct energy R&D for the public good
3. Reactive funding programs
4. Programs for demonstration, deployment, and engineering

West Coast Offshore Oil and Gas Workshop
January 08, 2003 Sidney BC



Program of Energy Research and Development
Programme de recherche et de développement énergétiques

Current Federal Energy Innovation Mechanisms



Program of Energy Research and Development
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The Energy Priority Framework (EPF)

- High level overview providing an environmental scan of energy related issues and related priorities cutting across Policy, Programs, and Science and Technology

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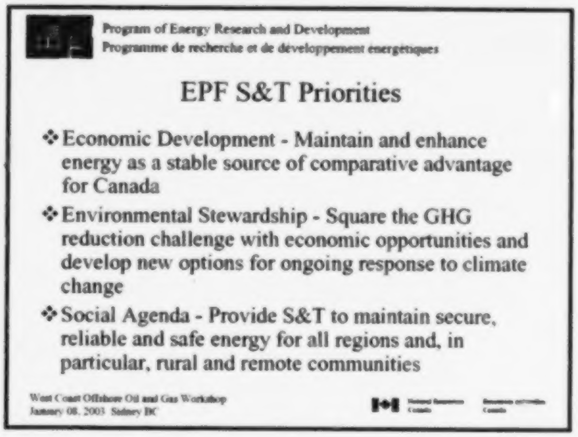

Program of Energy Research and Development
Programme de recherche et de développement énergétiques

EPF S&T Priorities

- ❖ Economic Development - Maintain and enhance energy as a stable source of comparative advantage for Canada
- ❖ Environmental Stewardship - Square the GHG reduction challenge with economic opportunities and develop new options for ongoing response to climate change
- ❖ Social Agenda - Provide S&T to maintain secure, reliable and safe energy for all regions and, in particular, rural and remote communities

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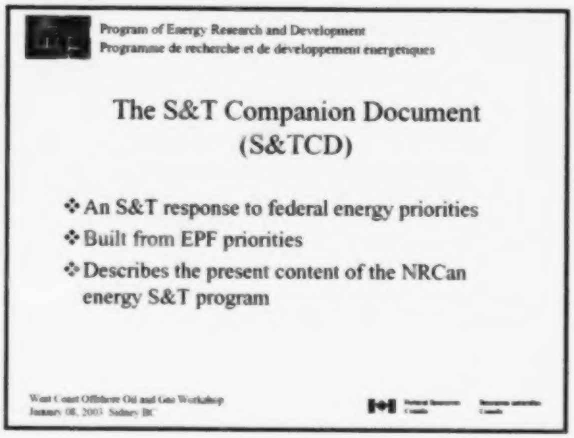

Program of Energy Research and Development
Programme de recherche et de développement énergétiques

The S&T Companion Document (S&TCD)

- ❖ An S&T response to federal energy priorities
- ❖ Built from EPF priorities
- ❖ Describes the present content of the NRCan energy S&T program

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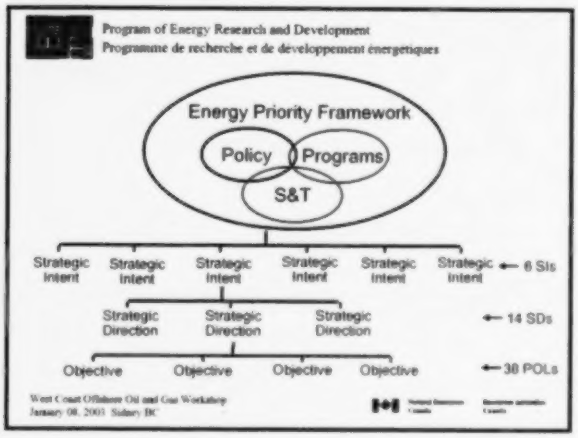

Program of Energy Research and Development
Programme de recherche et de développement énergétiques

Energy Priority Framework
Policy
Programs
S&T

Strategic Intent
Strategic Intent
Strategic Intent
Strategic Intent
Strategic Intent
Strategic Intent
← 6 SIs

Strategic Direction
Strategic Direction
Strategic Direction
← 14 SDs

Objective
Objective
Objective
Objective
← 38 POLs

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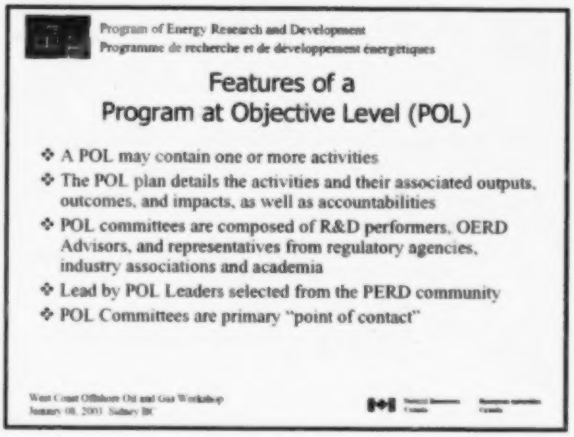

Program of Energy Research and Development
Programme de recherche et de développement énergétiques

Features of a Program at Objective Level (POL)

- ❖ A POL may contain one or more activities
- ❖ The POL plan details the activities and their associated outputs, outcomes, and impacts, as well as accountabilities
- ❖ POL committees are composed of R&D performers, OERD Advisors, and representatives from regulatory agencies, industry associations and academia
- ❖ Lead by POL Leaders selected from the PERD community
- ❖ POL Committees are primary "point of contact"

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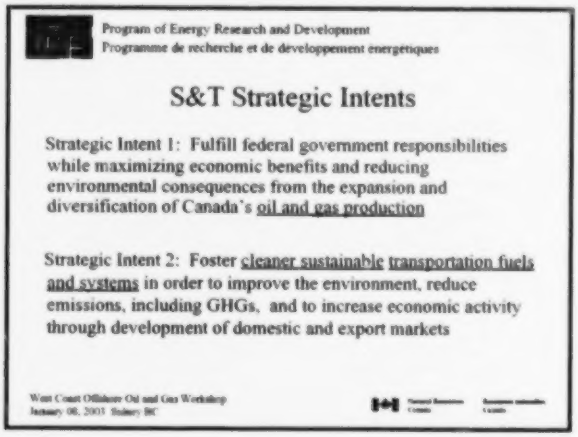

Program of Energy Research and Development
Programme de recherche et de développement énergétiques

S&T Strategic Intents

Strategic Intent 1: Fulfill federal government responsibilities while maximizing economic benefits and reducing environmental consequences from the expansion and diversification of Canada's oil and gas production

Strategic Intent 2: Foster cleaner sustainable transportation fuels and systems in order to improve the environment, reduce emissions, including GHGs, and to increase economic activity through development of domestic and export markets

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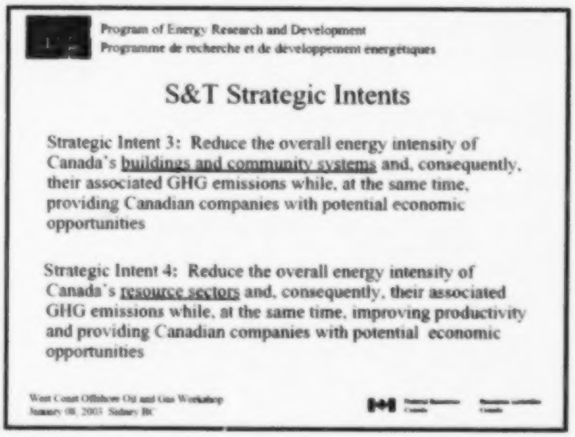

Program of Energy Research and Development
Programme de recherche et de développement énergétiques

S&T Strategic Intents

Strategic Intent 3: Reduce the overall energy intensity of Canada's buildings and community systems and, consequently, their associated GHG emissions while, at the same time, providing Canadian companies with potential economic opportunities

Strategic Intent 4: Reduce the overall energy intensity of Canada's resource sectors and, consequently, their associated GHG emissions while, at the same time, improving productivity and providing Canadian companies with potential economic opportunities

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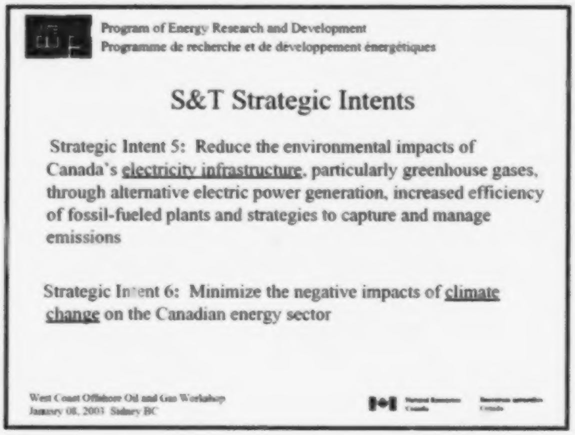

Program of Energy Research and Development
Programme de recherche et de développement énergétiques

S&T Strategic Intents

Strategic Intent 5: Reduce the environmental impacts of Canada's electricity infrastructure, particularly greenhouse gases, through alternative electric power generation, increased efficiency of fossil-fueled plants and strategies to capture and manage emissions

Strategic Intent 6: Minimize the negative impacts of climate change on the Canadian energy sector

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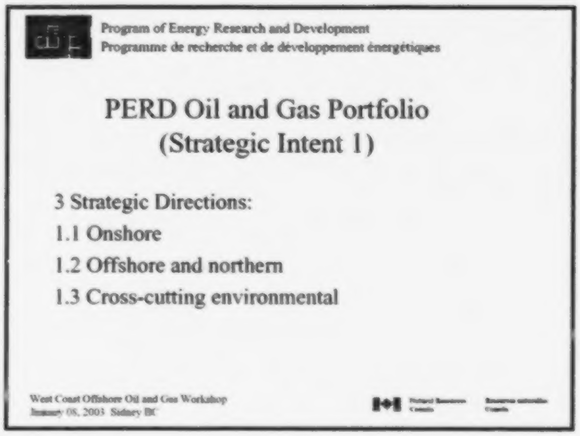

Program of Energy Research and Development
Programme de recherche et de développement énergétiques

PERD Oil and Gas Portfolio
(Strategic Intent 1)

3 Strategic Directions:
1.1 Onshore
1.2 Offshore and northern
1.3 Cross-cutting environmental

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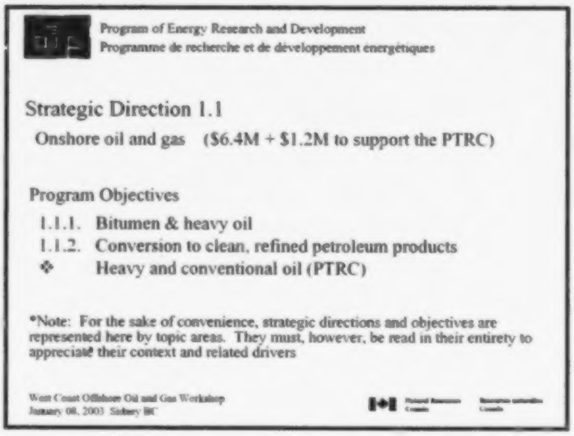

Program of Energy Research and Development
Programme de recherche et de développement énergétiques

Strategic Direction 1.1

Onshore oil and gas ($6.4M + $1.2M to support the PTRC)

Program Objectives

1.1.1. Bitumen & heavy oil
1.1.2. Conversion to clean, refined petroleum products
❖ Heavy and conventional oil (PTRC)

*Note: For the sake of convenience, strategic directions and objectives are represented here by topic areas. They must, however, be read in their entirety to appreciate their context and related drivers

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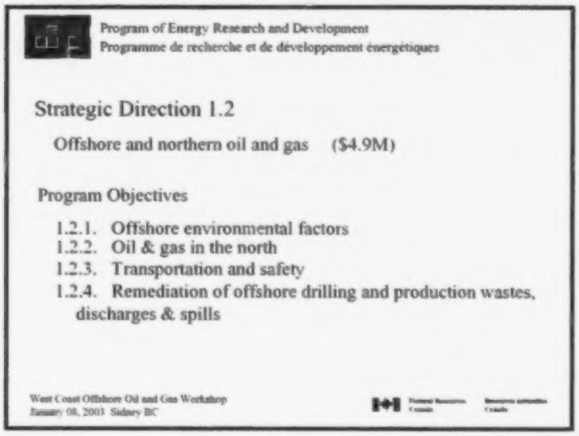

Program of Energy Research and Development
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Strategic Direction 1.2

Offshore and northern oil and gas ($4.9M)

Program Objectives

1.2.1. Offshore environmental factors
1.2.2. Oil & gas in the north
1.2.3. Transportation and safety
1.2.4. Remediation of offshore drilling and production wastes, discharges & spills

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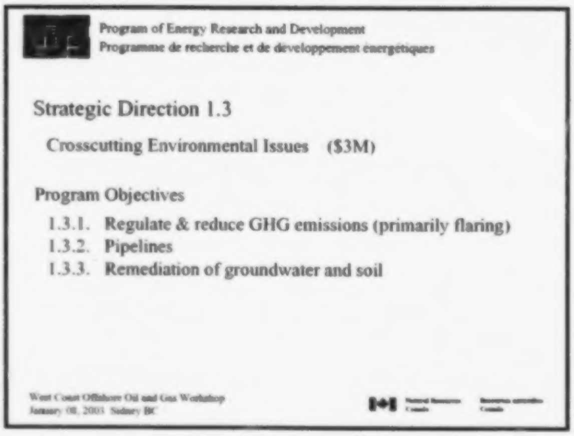

Program of Energy Research and Development
Programme de recherche et de développement énergétiques

Strategic Direction 1.3

Crosscutting Environmental Issues ($3M)

Program Objectives

1.3.1. Regulate & reduce GHG emissions (primarily flaring)
1.3.2. Pipelines
1.3.3. Remediation of groundwater and soil

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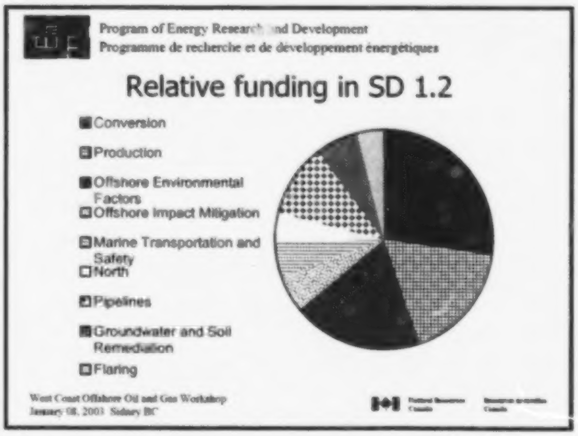

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Relative funding in SD 1.2

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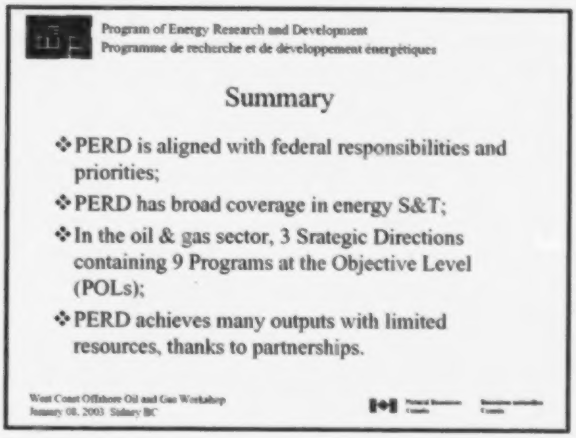


Program of Energy Research and Development
Programme de recherche et de développement énergétiques

Summary

- PERD is aligned with federal responsibilities and priorities;
- PERD has broad coverage in energy S&T;
- In the oil & gas sector, 3 Srategic Directions containing 9 Programs at the Objective Level (POLs);
- PERD achieves many outputs with limited resources, thanks to partnerships.

West Coast Offshore Oil and Gas Workshop
January 08, 2003 Sidney BC

Update on Centre for Offshore Oil and Gas Environmental Research (COOGER)

K. Lee

Fisheries and Oceans Canada

Centre for Offshore Oil and Gas Environmental Research
Centre de recherche environnementale sur le pétrole et le gaz extracôtiers

Background

- Canadian offshore oil and gas activities are expanding; many issues are emerging that require scientific knowledge to resolve.
- Research must be managed strategically by the Department to address our environmental and safety concerns related to offshore oil and gas development, exploration, and production.
- A multi-disciplinary, national approach is needed by DFO to optimize progress on current and future research initiatives and to maintain in-house expertise.

Background

- A-based funding has been limited. DFO makes significant in-kind contributions to support B-based programs (e.g. PERD and ESRF).
- New opportunities have resulted from external collaborations funded by C-Base and JPAs with industry, universities and other international government agencies.
- Need to optimize progress on research initiatives through national DFO coordination, building on existing regional expertise and infrastructure.

Role of COOGER

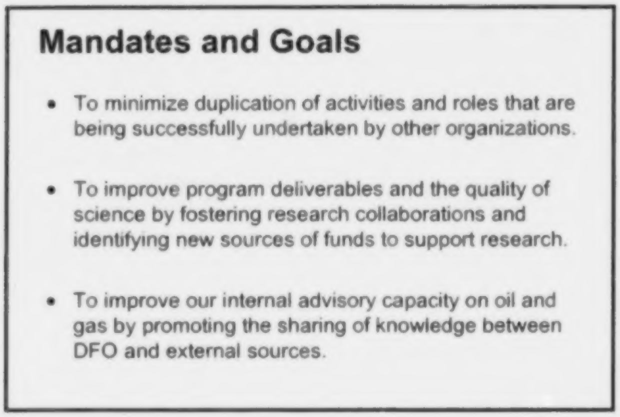
- Primary role:
  - Identification of R&D needs
  - Coordination of collaborative research internally and externally
  - Provision of scientific information to clients including Habitat, Oceans and Fisheries Management.

Role of COOGER

- The focus of COOGER is research.
- Review of Environmental Impact Assessments (EIAs) will be managed by regional oil and gas advisory committees.
- COOGER science members will provide advice and generic deliverables, such as science based frameworks for the review of EIAs.

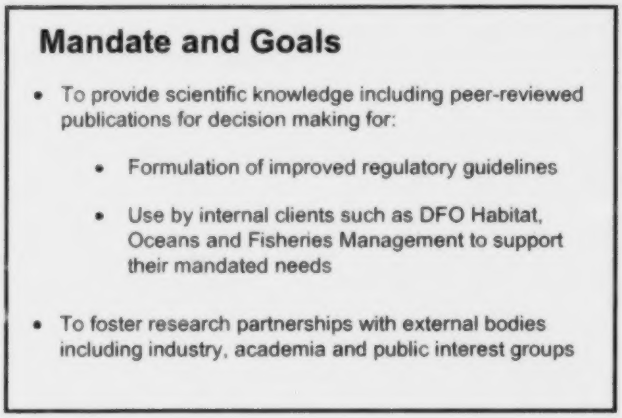
Mandate and Goals

- To facilitate the development of coordinated research programs in oceanographic research related to the environmental issues associated with oil and gas activities and DFO mandates.
- To identify needs for a balanced and strategic program on oil and gas research for the Department (e.g., providing advice on priorities to national science fund programs, and co-ordination of research proposal reviews).



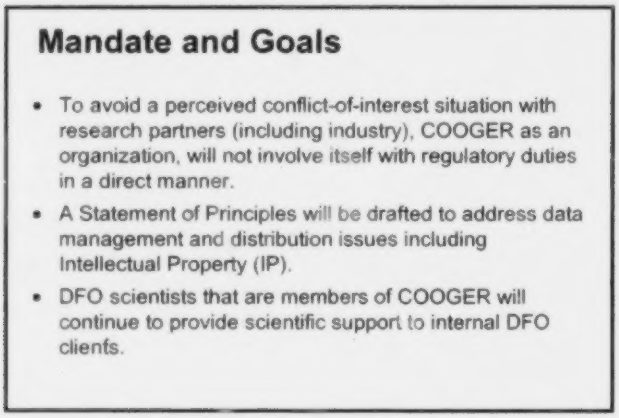
Mandates and Goals

- To minimize duplication of activities and roles that are being successfully undertaken by other organizations.
- To improve program deliverables and the quality of science by fostering research collaborations and identifying new sources of funds to support research.
- To improve our internal advisory capacity on oil and gas by promoting the sharing of knowledge between DFO and external sources.



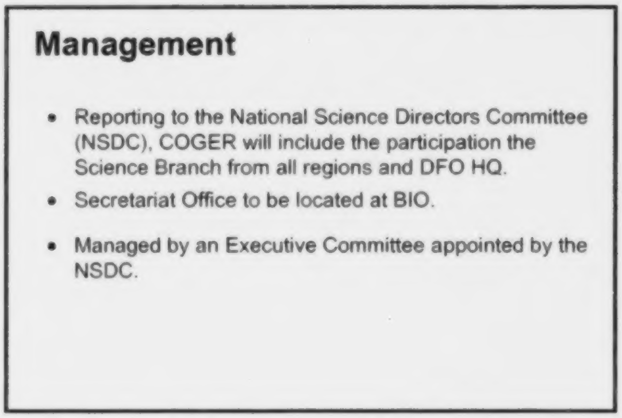
Mandate and Goals

- To provide scientific knowledge including peer-reviewed publications for decision making for:
  - Formulation of improved regulatory guidelines
  - Use by internal clients such as DFO Habitat, Oceans and Fisheries Management to support their mandated needs
- To foster research partnerships with external bodies including industry, academia and public interest groups



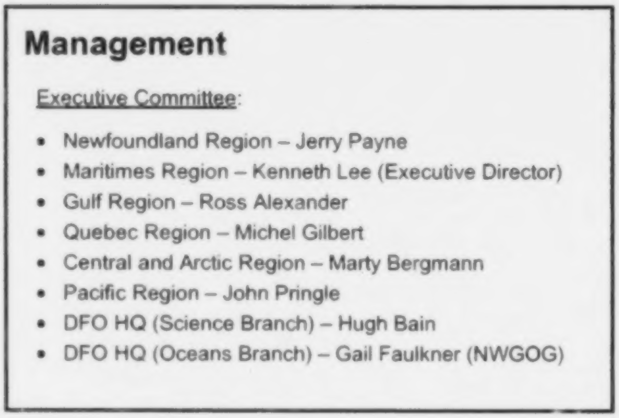
Mandate and Goals

- To avoid a perceived conflict-of-interest situation with research partners (including industry), COOGER as an organization, will not involve itself with regulatory duties in a direct manner.
- A Statement of Principles will be drafted to address data management and distribution issues including Intellectual Property (IP).
- DFO scientists that are members of COOGER will continue to provide scientific support to internal DFO clients.



Management

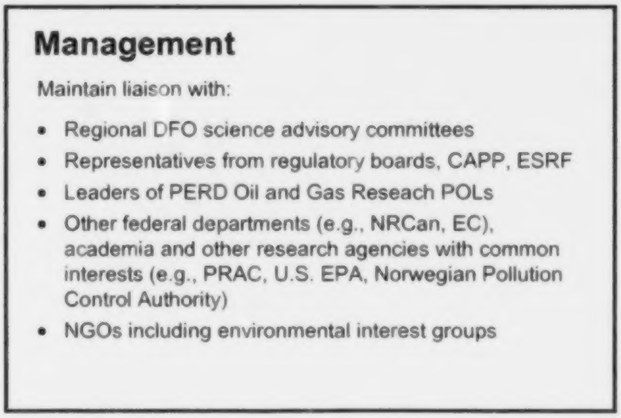
- Reporting to the National Science Directors Committee (NSDC), COGER will include the participation the Science Branch from all regions and DFO HQ.
- Secretariat Office to be located at BIO.
- Managed by an Executive Committee appointed by the NSDC.



Management

Executive Committee:

- Newfoundland Region – Jerry Payne
- Maritimes Region – Kenneth Lee (Executive Director)
- Gulf Region – Ross Alexander
- Quebec Region – Michel Gilbert
- Central and Arctic Region – Marty Bergmann
- Pacific Region – John Pringle
- DFO HQ (Science Branch) – Hugh Bain
- DFO HQ (Oceans Branch) – Gail Faulkner (NWGOG)



Management

Maintain liaison with:

- Regional DFO science advisory committees
- Representatives from regulatory boards, CAPP, ESRF
- Leaders of PERD Oil and Gas Reseach POLs
- Other federal departments (e.g., NRCan, EC), academia and other research agencies with common interests (e.g., PRAC, U.S. EPA, Norwegian Pollution Control Authority)
- NGOs including environmental interest groups

Discussion

The Centre for Offshore Oil and Gas Environmental Research (COOGER) facilitates co-ordination and communication both internally within DFO and externally. COOGER seeks mechanisms to optimise the use of departmental funds for oil and gas activities by identifying opportunities to lever programs through external partnerships with industry and academia. DFO may provide less than 50% of the required resources. Partners share ship-time and other resources and participate jointly in scientific cruises.

As an example of a COOGER project, the Atlantic Canada Opportunities Agency (ACOA) promotes research programs within the private sector. COOGER interacts with private industry organisations to identify opportunities for co-operation. ACOA has considered the funding of half a Person-Year (PY) to identify a crossover of interests where spin-offs from DFO research could be developed by industry into instrument packages for the commercial market.

The private sector has the responsibility to conduct research for the support of regulatory documents such as environmental impact statements (EIS's). As there is always an issue of public perception, industry has expressed an interest in funding and co-operating in research programs managed by COOGER to provide scientific information for use by resource managers in both parties and the public.

There is a need for data to support environmental assessment resulting from offshore oil and gas activity. Data include baseline physical (e.g., wind, waves, currents) and chemical (e.g., contaminant concentrations) information required for risk assessment. Industry is responsible for providing the necessary support but they realise that government has resources (e.g. research ships) and scientific expertise not otherwise available so partnerships can be advantageous to them.

On the West Coast, the proposed time frame for offshore oil and gas development is very short. Thus, a lot of ship time and other resources may be required in the near future. Much of this is considered the proponent's responsibility, but industry is unlikely to fund a substantial research effort until the moratorium has been lifted. There is no industry activity off the West Coast at the current time to provide support to programs under the Environmental Studies Research Fund (ESRF). The Government of Canada is looking at identifying the scientific information needs required to support decisions regarding the lifting of the moratorium. There is a balance between the lack of funding for data acquisition and the need for data to allow Ministers to make an informed decision regarding the moratorium.

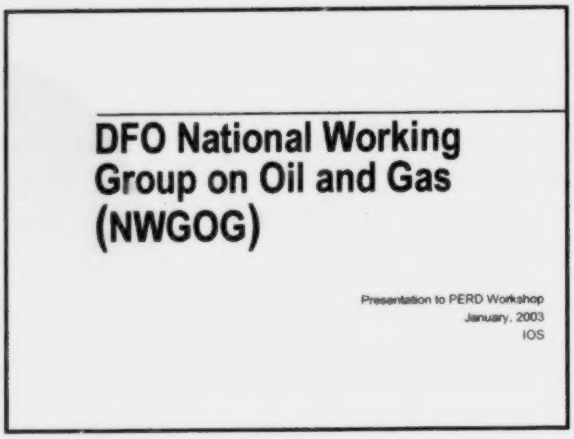
On the East Coast, industry has invested funds to obtain the information it needs and has become an active participant in the provision of advice to the PERD Program at Objective Level (POL) process. Industry does not fund ship time, expecting this to be provided by DFO, which has a value in the order of several hundred thousand dollars.

COOGER looks at two factors: the impact of the environment on offshore oil and gas activities and, secondly, the impact of oil and gas activities on the environment. COOGER programs are multi-disciplinary covering the biological, chemical, physical and geological sciences.

COOGER does not have programs specifically aimed at the West Coast at the present time, however, it does focus on identifying national science needs to cover oil and gas research requirements. For example, there are not enough scientists with risk assessment expertise. COOGER identifies the important issues, the key players and their roles. There are many shared concerns (e.g., seismics), many that are generic and are both national and international in scope. For example, in Nova Scotia, industry is now involved in deep water drilling operations. One concern is deep-water blowouts but this is also an international concern (e.g., the North Sea and the Gulf of Mexico). These issues should be dealt with through international programs involving DFO and other international organisations.

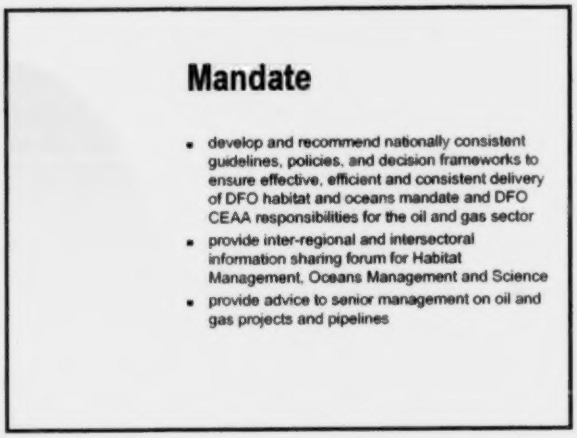
DFO National Working Group on Oil and Gas (NWGOG)

G. Faulkner
Fisheries and Oceans Canada



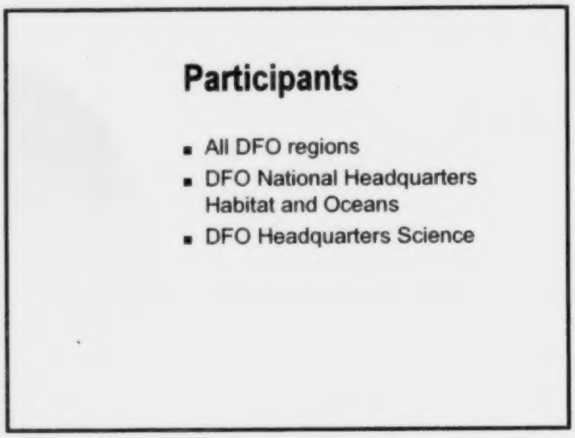
DFO National Working Group on Oil and Gas (NWGOG)

Presentation to PERD Workshop
January, 2003
IOS



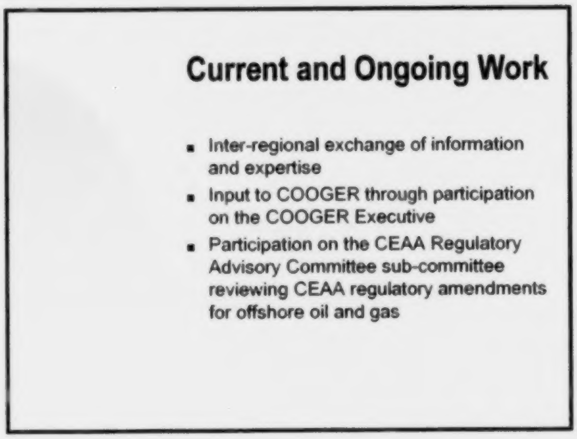
Mandate

- develop and recommend nationally consistent guidelines, policies, and decision frameworks to ensure effective, efficient and consistent delivery of DFO habitat and oceans mandate and DFO CEAA responsibilities for the oil and gas sector
- provide inter-regional and intersectoral information sharing forum for Habitat Management, Oceans Management and Science
- provide advice to senior management on oil and gas projects and pipelines



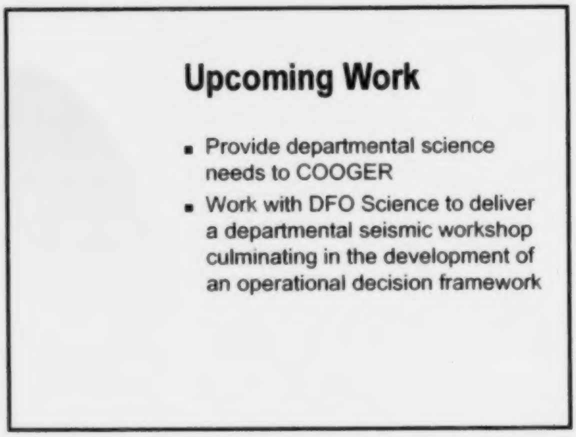
Participants

- All DFO regions
- DFO National Headquarters Habitat and Oceans
- DFO Headquarters Science



Current and Ongoing Work

- Inter-regional exchange of information and expertise
- Input to COOGER through participation on the COOGER Executive
- Participation on the CEAA Regulatory Advisory Committee sub-committee reviewing CEAA regulatory amendments for offshore oil and gas



Upcoming Work

- Provide departmental science needs to COOGER
- Work with DFO Science to deliver a departmental seismic workshop culminating in the development of an operational decision framework

Discussion

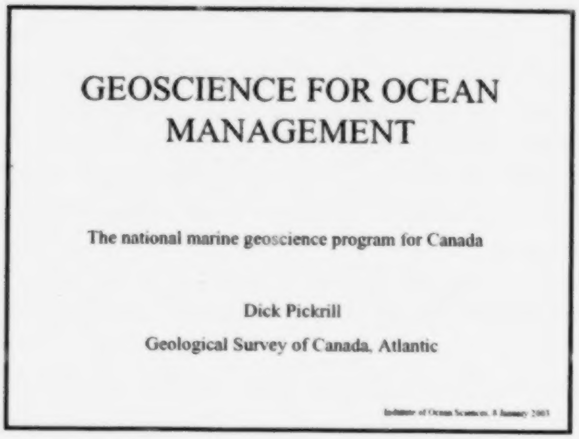
A seismic workshop will take place on March 20–22, 2003 in Montreal. The workshop will develop a decision-making framework to ensure that seismic operators provide correct information and that the decisions made are consistent. The workshop will lead operators through the decision-making process based on the information they provide. There will not be a peer review of existing knowledge. The workshop will draw on external expertise from Britain, U.S. and Canada, including scientists and regulators but not operators.

Concerning how the National Working Group on Oil and Gas relates to the Centre for Offshore Oil and Gas Environmental Research (COOGER), the National Working Group consists of decision-makers, managers and regulators. COOGER draws on scientists and research and development that support decision-making. It is important for COOGER to understand what the needs are internally within the department and to have crossover between science and regulators, with COOGER providing documents to assist decision making and policy development. In the future, it is likely that the two groups will develop Memoranda of Understanding (MOU) to define roles and commonalities.

Geoscience for Ocean Management

D. Pickrill

Natural Resources Canada



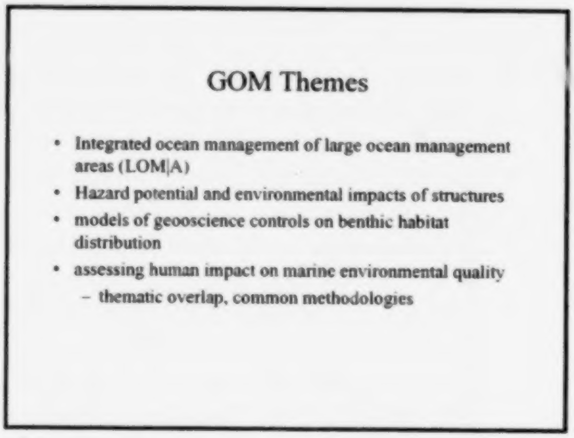
GEOSCIENCE FOR OCEAN MANAGEMENT

The national marine geoscience program for Canada

Dick Pickrill

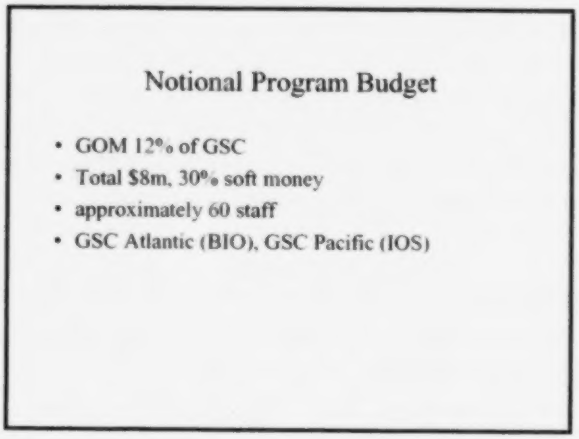
Geological Survey of Canada, Atlantic

Institute of Ocean Sciences, 8 January 2003



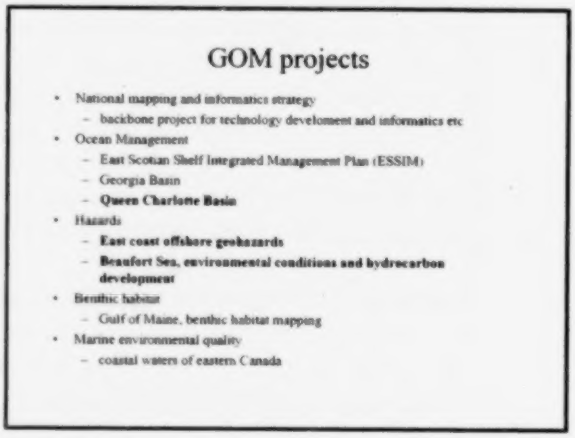
GOM Themes

- Integrated ocean management of large ocean management areas (LOM|A)
- Hazard potential and environmental impacts of structures
- models of geoscience controls on benthic habitat distribution
- assessing human impact on marine environmental quality
  - thematic overlap, common methodologies



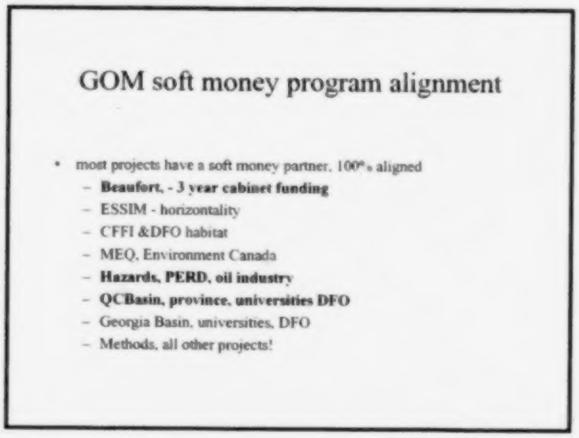
Notional Program Budget

- GOM 12% of GSC
- Total $8m, 30% soft money
- approximately 60 staff
- GSC Atlantic (BIO), GSC Pacific (IOS)



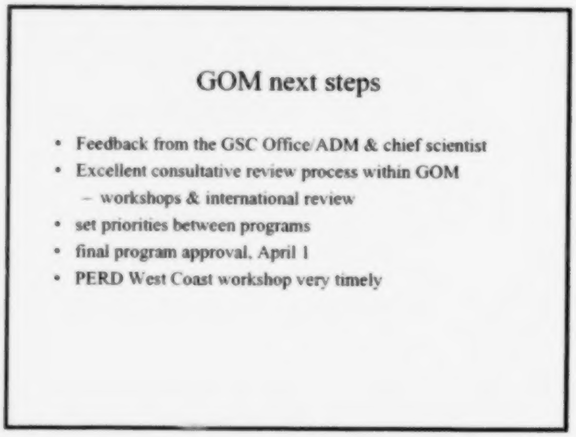
GOM projects

- National mapping and informatics strategy
  - backbone project for technology develoment and informatics etc
- Ocean Management
  - East Scotian Shelf Integrated Management Plan (ESSIM)
  - Georgia Basin
  - **Queen Charlotte Basin**
- Hazards
  - **East coast offshore geohazards**
  - **Beaufort Sea, environmental conditions and hydrocarbon development**
- Benthic habitat
  - Gulf of Maine, benthic habitat mapping
- Marine environmental quality
  - coastal waters of eastern Canada



GOM soft money program alignment

- most projects have a soft money partner, 100% aligned
  - **Beaufort, - 3 year cabinet funding**
  - ESSIM - horizontality
  - CFFI &DFO habitat
  - MEQ, Environment Canada
  - **Hazards, PERD, oil industry**
  - **QCBasin, province, universities DFO**
  - Georgia Basin, universities, DFO
  - Methods, all other projects!



GOM next steps

- Feedback from the GSC Office/ADM & chief scientist
- Excellent consultative review process within GOM
  - workshops & international review
- set priorities between programs
- final program approval, April 1
- PERD West Coast workshop very timely

Discussion

Historically, marine landslides and slumping have been big issues, with studies directed toward the more active areas. In some of the canyons, backscatter from multibeam sonar has shown sand ripples at 300 m depth. On multibeam, six to ten distributory channels can be seen at the head of canyons where charts show a single channel. Sediment can be seen feeding into the channels. In general, 90% of the slope is satisfactory and focus is on the remaining 10%. There is enough information at the moment to get past the exploratory phase. The exploratory phase is much different than the production phase. During exploration there is drilling activity on site for perhaps 25 days and the risk from landslides is acceptable. Production structures are a different situation. There are examples of threats from sea slope failure. In the Gulf, slope failure occurred near a platform as illustrated by the slide of a sidescan mosaic, which showed a mudslide reaching a distance of 10-100 m from the platform.

Interactions between Geology and Habitat

There has been co-operation with the fishing industry (Clearwater Fine Foods, scallop producers) and DFO (Canadian Hydrographic Service and Fisheries Management Sector). Vladimir Kostilov has conducted habitat mapping under contract with funds from NRCan and DFO. A paper in *Marine Ecology* is in progress. The work established strong statistical links between substrate and benthic community structure that can then be mapped quickly with reasonable precision. To date, the emphasis has been on benthic communities, with the intent to move on to scallops. A full two-year, $6 million, multibeam dataset has been funded by industry. It is intended to produce high-resolution habitat maps over the Banks in the next two years.

Sediment motion has been seen at depths up to 30 m. There is a need to put sensors on platforms and to obtain data during storms. On the East Coast, there has been apparent remobilization at the shelf break, which is possibly due to internal waves. This would not apply to the West Coast, where much higher wave energy would be required.

The digital atlas includes data sets from NRCan and industry but not other departments because the work has been largely confined to the Geoscience Centre. An initiative between the two departments will try to meld data, which include benthic ecology, geology and the most recent bathymetry. New maps are planned that will have 10-15 different surfaces on a CD-ROM. There are two and a half years to go on this project.

Environmental Studies Research Funds

Overview & East Coast Projects

K. Lee

Fisheries and Oceans Canada

Environmental Studies Research Funds

Overview &
East Coast projects

Environmental Studies Research Funds

Overview

Profile

- The Environmental Studies Research Funds (ESRF) is a research program which sponsors environmental and social studies
- It is designed to assist in the decision-making process related to oil and gas exploration and development on Canada's frontier lands

Profile - continued

- The ESRF program, initiated in 1983, receives its legislative mandate through the *Canada Petroleum Resources Act* (CPRA)
- Funding is provided through levies on frontier lands paid by interested holders such as the oil and gas companies

Profile - continued

- The ESRF provides a forum for industry and government to develop a common knowledge base and to jointly design a focused study program which addresses the needs of both groups and avoids a repetition of effort and expense

Purpose

- To finance environmental and social studies pertaining to the manner in which and to the terms and conditions under which petroleum exploration, development, and production activities on frontier lands should be conducted.

Management

- Directed by a 12-member Management Board with representation from:
  - – the federal government (4)
  - – the Canada-Newfoundland Offshore Petroleum Board (1)
  - – the Canada-Nova Scotia Offshore Petroleum Board (1)
  - – the oil and gas industry (4)
  - – the general public (2)

Management - continued

- Bonnie Gray, Professional Leader of Environment at the National Energy Board (NEB) currently chairs the ESRF Management Board.
- Administration is provided by a small secretariat within the NEB.

Management Board

- Sets priorities for study topics
- Determines the program budget
- Facilitates the development of study proposals

Environmental Studies Research Funds

Recent East Coast Projects

Priority Study Areas

- Offshore Waste Discharges
- Offshore Seismic Operations
- Seabirds
- Cumulative Effects
- Environmental Effects Monitoring
- Dispersants/Oil Spill Management Response
- Environmental Prediction (Weather)/Physical Environment
- Subsea Gathering Line/Pipeline Effects

Stand-Alone Studies (2002)

(not directly linked to a priority area)

- Iceberg Scour
- Deepwater Corals
- CSA Structures
- Mesocosm/Drill cuttings

Ongoing or Planned Studies

- Cumulative Effects Workshop
- Mapping of Sensitive Fisheries Areas - Nova Scotia and Newfoundland
- Effects of Seismic Energy on Snow Crab
- Seabird and Marine Mammal Study
- Sheens and Produced Water
- Pollution Prevention Opportunities

Studies - continued

- Standardizing Reporting of Air Emissions
- EEM for Exploratory Drilling
- Seabird Attraction to production Installations - Instrument-based Approaches
- Chemical Dispersant-use Workshop

Publications

- All ESRF studies are subject to a scientific/technical peer review
- Reports that are deemed to be scientifically or technically significant are published in the ESRF Technical Report Series.

Publications - continued

- Complete list of study reports published since 1983 is contained in the ESRF Annual Report
- Copies are available from the ESRF Secretariat

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Discussion

When offshore lands are leased, a contribution is made to the ESRF Fund. Money for the support of research on the West Coast under the ESRF Fund is not anticipated until the start of operations following a lifting of the moratorium. Bidding on ESRF projects is wide open, with many projects are carried out by private sector companies. ESRF is very specific about what their needs are. The process involves identifying the need and objectives and a bid call is posted. At the present time, DFO, Environment Canada and industry representatives are members of the ESRF Advisory Committees. Historically, it was intended that ESRF money would not fund government research, and only recently has the fund become available to federal laboratories. Scientific information produced under the ESRF program is now published in peer reviewed reports. This is in response to reviewers of Environmental Impact Statements (EIA) who do not accept citations from the grey literature.

PERD and ESRF differ in that ESRF topics are very specific and short-term while PERD projects are longer term. For example, there was an incident in the Gulf of Mexico involving mercury in drilling mud. ESRF very quickly had a project to look at mercury issues. Requests for Proposals (RFPs) under the ESRF program are very focused and specific while the PERD call for proposals are for much broader tasks.

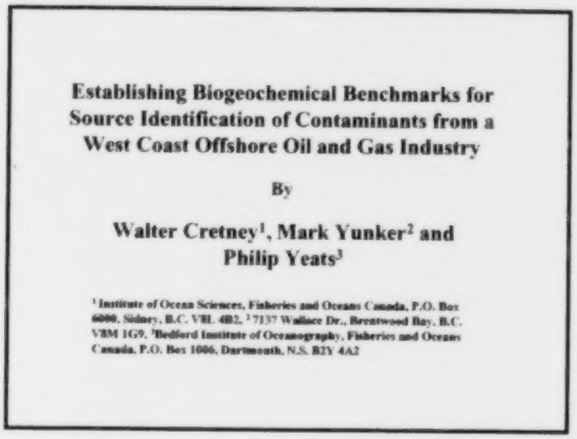
To give you an idea of ESRF funding levels, the Deep Sea Corals Project received $130K in 2003 and another project was about $200K, so funding at $50-200K is typical.

Potential perception problems could exist where work is industry-driven and funded. All parties want to be ensured that results are reliable and acceptable. Under ESRF programs, the data on which reports are based are open. Data are not proprietary and reports are peer-reviewed
No funds are available until industry indicates interest in an area and exploration starts. Scientists are in a quandary as there is no opportunity or funding to do baseline studies; everything has to happen at once. There is no easy way around this as people do not want to invest unless there is potential for things moving forward. We need to keep in mind this workshop is looking at the needs in relation to exploration on the West Coast as opposed to production.

Establishing Biogeochemical Benchmarks for Source Identification of Contaminants from a West Coast Offshore Oil and Gas Industry

W. Cretney

Fisheries and Oceans Canada

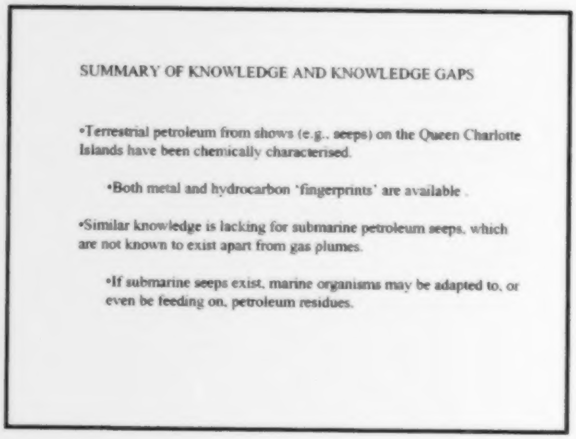


Establishing Biogeochemical Benchmarks for Source Identification of Contaminants from a West Coast Offshore Oil and Gas Industry

By

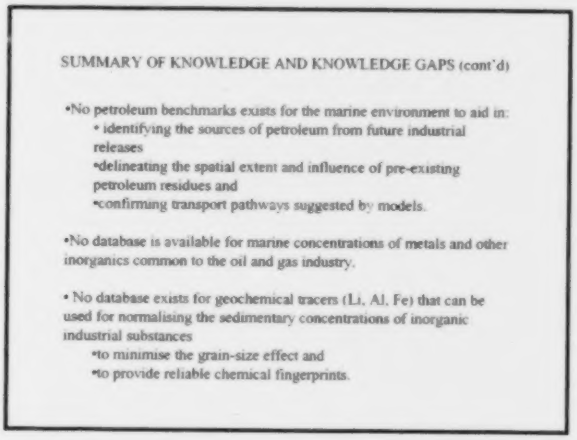
Walter Cretney[1], Mark Yunker[2] and Philip Yeats[3]

[1] Institute of Ocean Sciences, Fisheries and Oceans Canada, P.O. Box 6000, Sidney, B.C. V8L 4B2, [2] 7137 Wallace Dr., Brentwood Bay, B.C. V8M 1G9, [3]Bedford Institute of Oceanography, Fisheries and Oceans Canada, P.O. Box 1006, Dartmouth, N.S. B2Y 4A2



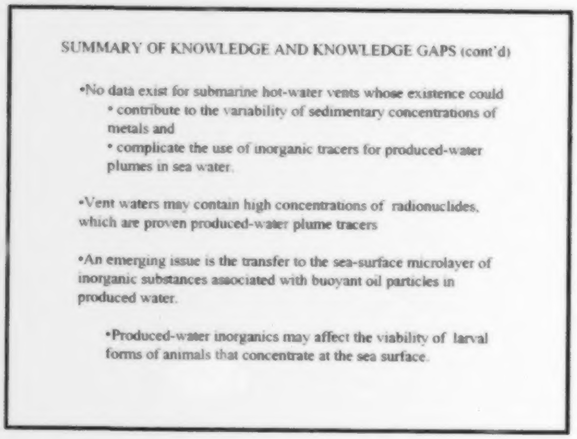
SUMMARY OF KNOWLEDGE AND KNOWLEDGE GAPS

- Terrestrial petroleum from shows (e.g., seeps) on the Queen Charlotte Islands have been chemically characterised.
  - Both metal and hydrocarbon 'fingerprints' are available .
- Similar knowledge is lacking for submarine petroleum seeps, which are not known to exist apart from gas plumes.
  - If submarine seeps exist, marine organisms may be adapted to, or even be feeding on, petroleum residues.



SUMMARY OF KNOWLEDGE AND KNOWLEDGE GAPS (cont'd)

- No petroleum benchmarks exists for the marine environment to aid in:
  - identifying the sources of petroleum from future industrial releases
  - delineating the spatial extent and influence of pre-existing petroleum residues and
  - confirming transport pathways suggested by models.
- No database is available for marine concentrations of metals and other inorganics common to the oil and gas industry.
- No database exists for geochemical tracers (Li, Al, Fe) that can be used for normalising the sedimentary concentrations of inorganic industrial substances
  - to minimise the grain-size effect and
  - to provide reliable chemical fingerprints.



SUMMARY OF KNOWLEDGE AND KNOWLEDGE GAPS (cont'd)

- No data exist for submarine hot-water vents whose existence could
  - contribute to the variability of sedimentary concentrations of metals and
  - complicate the use of inorganic tracers for produced-water plumes in sea water.
- Vent waters may contain high concentrations of radionuclides, which are proven produced-water plume tracers
- An emerging issue is the transfer to the sea-surface microlayer of inorganic substances associated with buoyant oil particles in produced water.
  - Produced-water inorganics may affect the viability of larval forms of animals that concentrate at the sea surface.

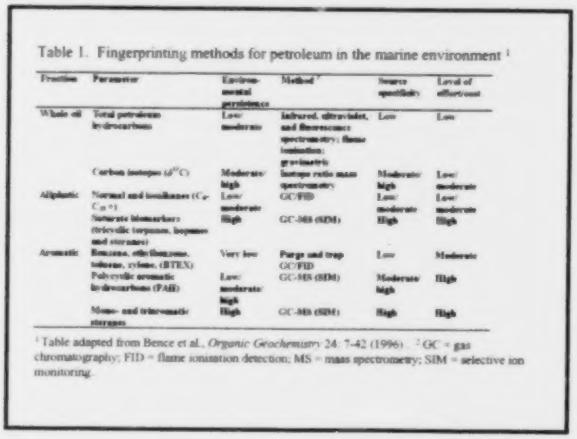


Table 1. Fingerprinting methods for petroleum in the marine environment [1]

Fraction	Parameter	Environmental persistence	Method [2]	Source specificity	Level of effort/cost
Whole oil	Total petroleum hydrocarbons	Low/ moderate	Infrared, ultraviolet, and fluorescence spectrometry; flame ionisation; gravimetric	Low	Low
	Carbon isotopes ($\delta^{13}C$)	Moderate/ high	Isotope ratio mass spectrometry	Moderate/ high	Low/ moderate
Aliphatic	Normal and isoalkanes (C_8-C_{40}+)	Low/ moderate	GC/FID	Low/ moderate	Low/ moderate
	Saturate biomarkers (tricyclic terpanes, hopanes and steranes)	High	GC-MS (SIM)	High	High
Aromatic	Benzene, ethylbenzene, toluene, xylene, (BTEX)	Very low	Purge and trap GC/FID	Low	Moderate
	Polycyclic aromatic hydrocarbons (PAH)	Low/ moderate/ high	GC-MS (SIM)	Moderate/ high	High
	Mono- and triaromatic steranes	High	GC-MS (SIM)	High	High

[1] Table adapted from Bence et al., *Organic Geochemistry* 24: 7-42 (1996) . [2] GC = gas chromatography; FID = flame ionisation detection; MS = mass spectrometry; SIM = selective ion monitoring.

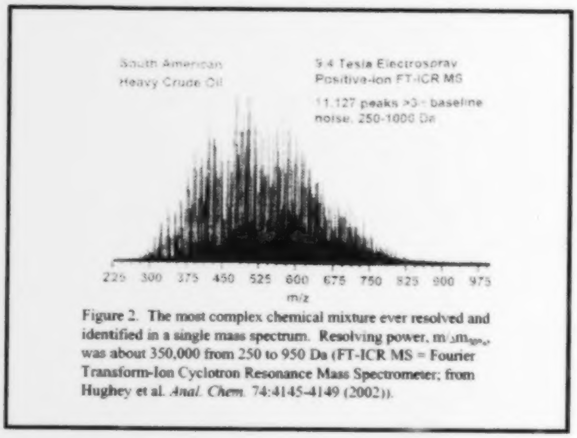


Figure 2. The most complex chemical mixture ever resolved and identified in a single mass spectrum. Resolving power, $m/\Delta m_{50\%}$, was about 350,000 from 250 to 950 Da (FT-ICR MS = Fourier Transform-Ion Cyclotron Resonance Mass Spectrometer; from Hughey et al. *Anal. Chem.* 74:4145-4149 (2002)).

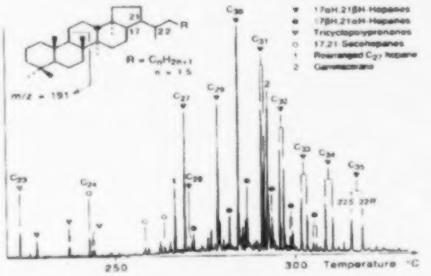


Figure 3. Mass fragmentogram (m/z 191) showing the distribution of polycyclic terpanes separated by temperature-programmed gas chromatography (from Ourisson and Albrecht *Acc. Chem. Res.* 25:398-402 (1992))

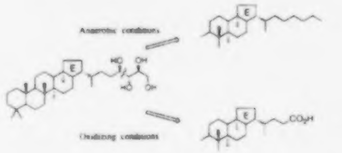


Figure 4. Diagenic transformation of bacteriohopanetetrol under anaerobic and aerobic conditions (from Ourisson and Albrecht *Acc. Chem. Res.* 25:398-402 (1992))

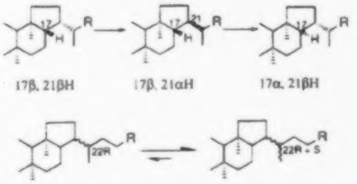


Figure 5. Structural changes in hopanoids with time and temperature. The ratios of diasteriomers ([áà]:[áa]:[àá]) provide a measure of "maturity" (from Ourisson and Albrecht *Acc. Chem. Res.* 25:398-402 (1992))

Figure 6. Formation of tetra- and pentacyclic aromatic hydrocarbons from α-amyrin (Cranwell, *Prog. Lipid Res.* 21: 271-308 (1982))

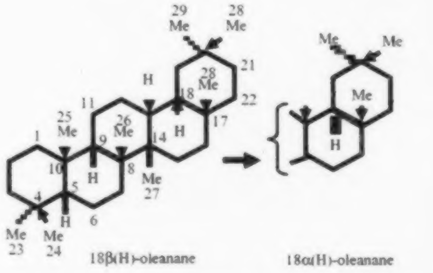


Figure 9. Conversion of 18β(H)-oleanane to its more thermodynamically stable epimer 18α(H)-oleanane

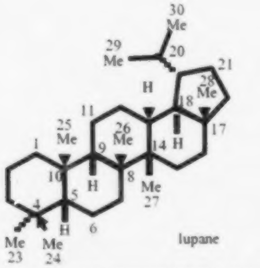


Figure 10. Lupane is a geometric isomer of 18α(H)-oleanane that coelutes with it on non-polar gas chromatography columns

Table 5. Inorganic chemical composition of produced water compared with hotspring and sea water

	Produced water[1]	Hotspring Island thermal water[2]	Sea water[3]
Salinity	1-225 ‰	3.32 ‰	27.1-34.1 ‰
NH3	0-14 mM	No data	No data
SiO2	250 µM	1600 µM	0.6-80.3 µM
Al	0.07-2.3 mg/L	0.6 mg/L	30-130 ng/L
Fe	0.12-600 mg/L	No data	4-140 ng/L
Mn	0.11-11 mg/L	No data	50-70 ng/L
Ba	0.2-342 mg/L	0.2 mg/L	4-20 µg/L
Cd	0.05-190 µg/L	No data	0.8-100 ng/L
Cu	0.2-800 µg/L	No data	0.08-0.13 µg/L
Hg	0.01-7 µg/L	No data	0.5 ng/L
Pb	0.1-880 µg/L	No data	3-9 ng/L
Zn	0.26-69000 µg/L	No data	4-500 ng/L
Ra-226	0.1-1565 pCi/L	No data	0.03-0.045 pCi/L
Ra-228	0.6-1500 pCi/L	No data	0.006 pCi/L

[1] compiled from various sources, [2] Clark, I.D. 1985. Geochemistry, isotope hydrogeology and geothermometry of hotsprings in the northern coastal area of British Columbia. Geological Survey of Canada, unpublished contractor report. [3] Ocean Science and Productivity (OSAP) Division archive, IOS, data for Queen Charlotte Basin area (water depth < 400 m).

RECOMMENDATIONS

•A guideline document must be prepared for the establishment of benchmarks for petroleum biomarkers and metals to permit source identification of acute and chronic emissions from an offshore oil and gas industry in B.C.

•Guidelines should refer to, but not be limited to, the petroleum compounds and chemical elements discussed in this report.

•Guidelines should recognise that source identification methods are evolving and that new or refined procedures are likely to be available when work begins to establish petroleum benchmarks.

RECOMMENDATIONS (cont'd)

•Preparation of adequate benchmarks will require advance survey work to characterise the existing petroleum signatures in sediments, seawater and biota in areas where new drilling is likely.

•Baseline studies must be completed and the benchmark profiles must be established prior to the commencement of drilling activities.

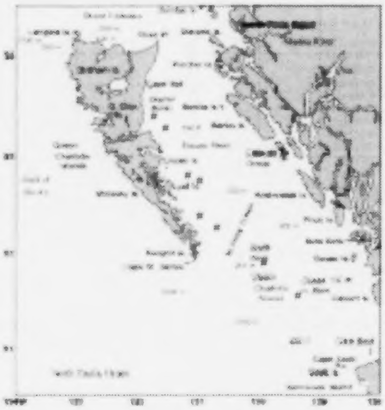


Figure 1. Geographical region of Queen Charlotte Assessment area

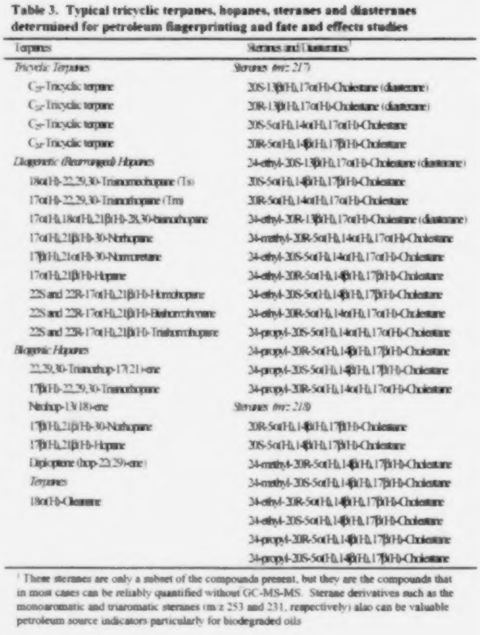


Table 3. Typical tricyclic terpanes, hopanes, steranes and diasteranes determined for petroleum fingerprinting and fate and effects studies

Terpanes	Steranes and Diasteranes[1]
Tricyclic Terpanes	*Steranes (m/z 217)*
C_{23}-Tricyclic terpane	20S-13β(H),17α(H)-Cholestane (diasterane)
C_{24}-Tricyclic terpane	20R-13β(H),17α(H)-Cholestane (diasterane)
C_{25}-Tricyclic terpane	20S-5α(H),14α(H),17α(H)-Cholestane
C_{26}-Tricyclic terpane	20R-5α(H),14β(H),17β(H)-Cholestane
Diagenetic (Rearranged) Hopanes	24-ethyl-20S-13β(H),17α(H)-Cholestane (diasterane)
18α(H)-22,29,30-Trisnorneohopane (Ts)	20S-5α(H),14β(H),17β(H)-Cholestane
17α(H)-22,29,30-Trisnorhopane (Tm)	20R-5α(H),14α(H),17α(H)-Cholestane
17α(H),18α(H),21β(H)-28,30-bisnorhopane	24-ethyl-20R-13β(H),17α(H)-Cholestane (diasterane)
17α(H),21β(H)-30-Norhopane	24-methyl-20R-5α(H),14α(H),17α(H)-Cholestane
17β(H),21α(H)-30-Normoretane	24-ethyl-20S-5α(H),14α(H),17α(H)-Cholestane
17α(H),21β(H)-Hopane	24-ethyl-20R-5α(H),14β(H),17β(H)-Cholestane
22S and 22R-17α(H),21β(H)-Homohopane	24-ethyl-20S-5α(H),14β(H),17β(H)-Cholestane
22S and 22R-17α(H),21β(H)-Bishomohopane	24-ethyl-20R-5α(H),14α(H),17α(H)-Cholestane
22S and 22R-17α(H),21β(H)-Trishomohopane	24-propyl-20S-5α(H),14α(H),17α(H)-Cholestane
Biogenic Hopanes	24-propyl-20R-5α(H),14β(H),17β(H)-Cholestane
22,29,30-Trisnorhop-17(21)-ene	24-propyl-20S-5α(H),14β(H),17β(H)-Cholestane
17β(H)-22,29,30-Trisnorhopane	24-propyl-20R-5α(H),14α(H),17α(H)-Cholestane
Neohop-13(18)-ene	*Steranes (m/z 218)*
17β(H),21β(H)-30-Norhopane	20R-5α(H),14β(H),17β(H)-Cholestane
17β(H),21β(H)-Hopane	20S-5α(H),14β(H),17β(H)-Cholestane
Diploptene (hop-22(29)-ene)	24-methyl-20R-5α(H),14β(H),17β(H)-Cholestane
Terpanes	24-methyl-20S-5α(H),14β(H),17β(H)-Cholestane
18α(H)-Oleanane	24-ethyl-20R-5α(H),14β(H),17β(H)-Cholestane
	24-ethyl-20S-5α(H),14β(H),17β(H)-Cholestane
	24-propyl-20R-5α(H),14β(H),17β(H)-Cholestane
	24-propyl-20S-5α(H),14β(H),17β(H)-Cholestane

[1] These steranes are only a subset of the compounds present, but they are the compounds that in most cases can be reliably quantified without GC-MS-MS. Sterane derivatives such as the monoaromatic and triaromatic steranes (m/z 253 and 231, respectively) also can be valuable petroleum source indicators particularly for biodegraded oils

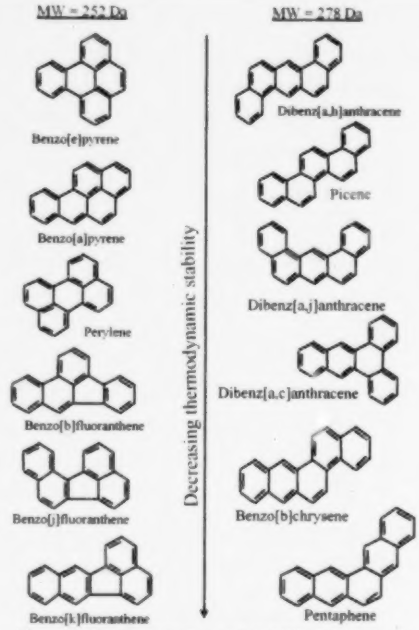


Figure 7. PAH structures and stability (Yunker et al., *Org. Geochem.* 33:489-515 (2002))

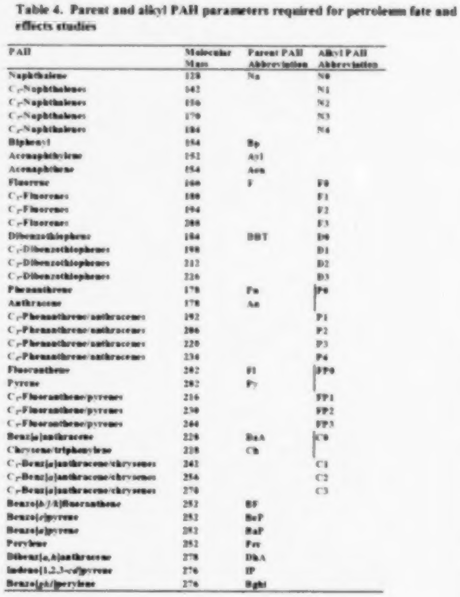


Table 4. Parent and alkyl PAH parameters required for petroleum fate and effects studies

PAH	Molecular Mass	Parent PAH Abbreviation	Alkyl PAH Abbreviation
Naphthalene	128	Na	N0
C_1-Naphthalenes	142		N1
C_2-Naphthalenes	156		N2
C_3-Naphthalenes	170		N3
C_4-Naphthalenes	184		N4
Biphenyl	154	Bp	
Acenaphthylene	152	Ayl	
Acenaphthene	154	Ace	
Fluorene	166	F	F0
C_1-Fluorenes	180		F1
C_2-Fluorenes	194		F2
C_3-Fluorenes	208		F3
Dibenzothiophene	184	DBT	D0
C_1-Dibenzothiophenes	198		D1
C_2-Dibenzothiophenes	212		D2
C_3-Dibenzothiophenes	226		D3
Phenanthrene	178	Pn	P0
Anthracene	178	An	
C_1-Phenanthrene/anthracenes	192		P1
C_2-Phenanthrene/anthracenes	206		P2
C_3-Phenanthrene/anthracenes	220		P3
C_4-Phenanthrene/anthracenes	234		P4
Fluoranthene	202	Fl	FP0
Pyrene	202	Py	
C_1-Fluoranthene/pyrenes	216		FP1
C_2-Fluoranthene/pyrenes	230		FP2
C_3-Fluoranthene/pyrenes	244		FP3
Benz[*a*]anthracene	228	BaA	C0
Chrysene/triphenylene	228	Ch	
C_1-Benz[*a*]anthracene/chrysenes	242		C1
C_2-Benz[*a*]anthracene/chrysenes	256		C2
C_3-Benz[*a*]anthracene/chrysenes	270		C3
Benzo[*b*/*j*/*k*]fluoranthene	252	BF	
Benzo[*e*]pyrene	252	BeP	
Benzo[*a*]pyrene	252	BaP	
Perylene	252	Per	
Dibenz[*a*,*h*]anthracene	278	DbA	
Indeno[1,2,3-*cd*]pyrene	276	IP	
Benzo[*ghi*]perylene	276	Bghi	

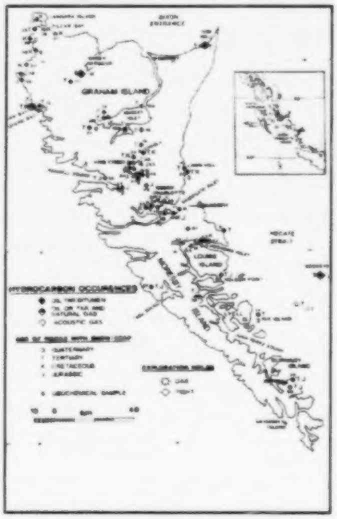


Figure 8. Hydrocarbon Occurrences, Queen Charlotte Islands (from Hamilton and Cameron *Bull. Can. Petrol. Geol.* 37:443-466 (1989))

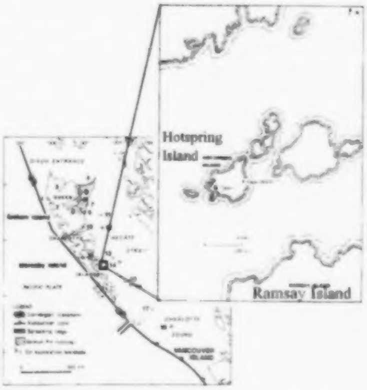


Figure 11. Location of hotsprings on Hotspring Island. (main from Whiticar, M.J. 2002. Appendix 6. *In*: British Columbia Offshore Hydrocarbon Development: appendices to the Report of the Scientific Review Panel. Ministry of Energy and Mines, Victoria, B.C., pp. 26-36. Insert from McDonald et al. 1978. "Hotsprings of Western Canada: A Complete Guide.")

Discussion

To establish a sufficiently robust model to detect hydrocarbons originating from drilling activity, a solid data baseline of water, sediments and possibly the surface is required. Since many compounds are correlated, a significant amount of data can be provided by a smaller subset of samples. When running GCMS analysis, it is not much more work or expense to obtain information on all resolved components rather than a limited number of target compounds.

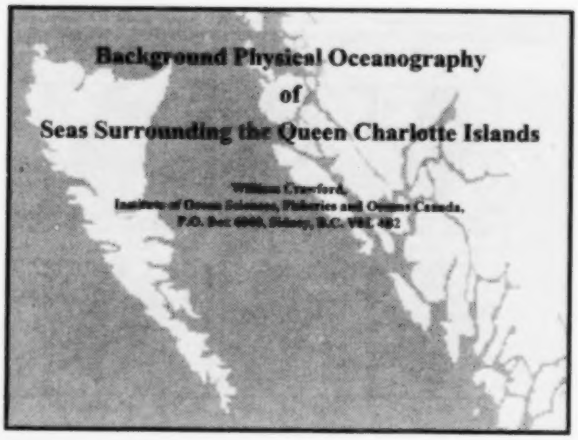
Tar balls are found on beaches on Queen Charlotte Island. Balls are mobile and come from local seeps, ships, or seeps located elsewhere (e.g., Alaska). Information on currents would be useful in determining their possible sources.

To date, many of the previous test wells in BC were dry, but there were traces of hydrocarbons in the strata. The figure of 10 billion barrels has been used based on potential play analysis. Note that at the present time there are no "reserves", only potential. The estimate could now differ from that of the late 1980s as the potential was based on information available at that time. When the seismics from Shell and Chevron are compared, one realises that interpretation depends on the analysis techniques used. There is lots of room for 14 dry holes.

Before drilling on the East Coast, industry did extensive baseline work on hydrocarbons and metals for monitoring programs. It is up to DFO and other agencies to provide guidelines. There is a need to establish the biological relevance of the compounds sampled and to provide really good fingerprints for source information.

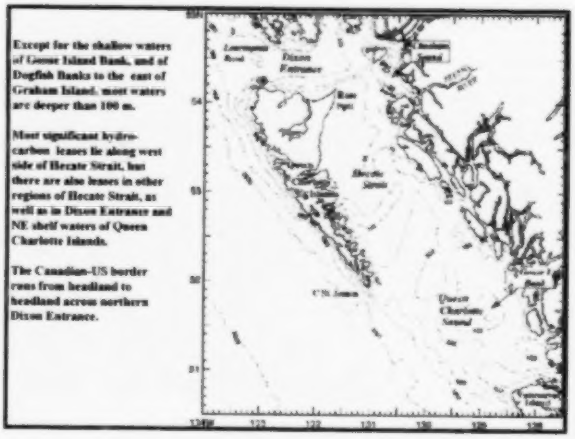
Background Physical Oceanography of Seas Surrounding the Queen Charlotte Islands

B. Crawford
Fisheries and Oceans Canada



Background Physical Oceanography
of
Seas Surrounding the Queen Charlotte Islands

William Crawford,
Institute of Ocean Sciences, Fisheries and Oceans Canada,
P.O. Box 6000, Sidney, B.C. V8L 4B2



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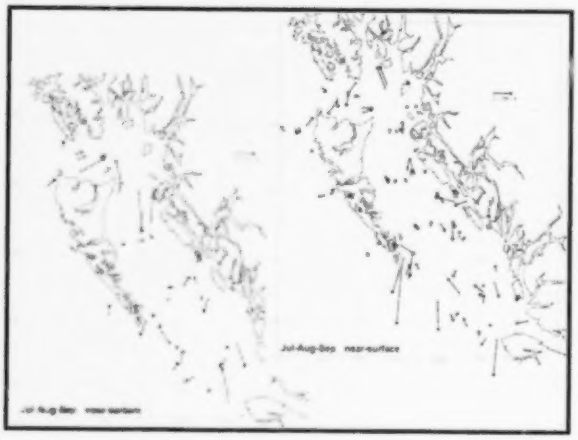
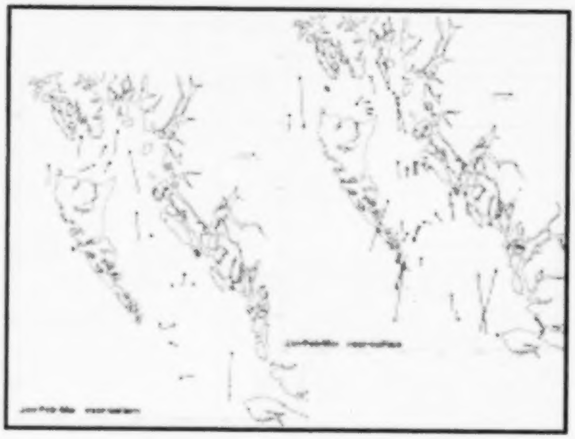
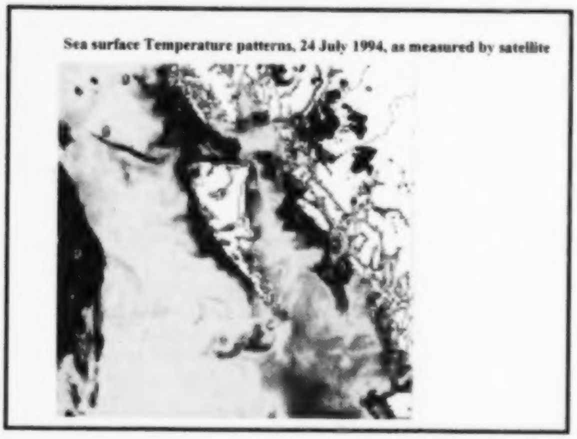
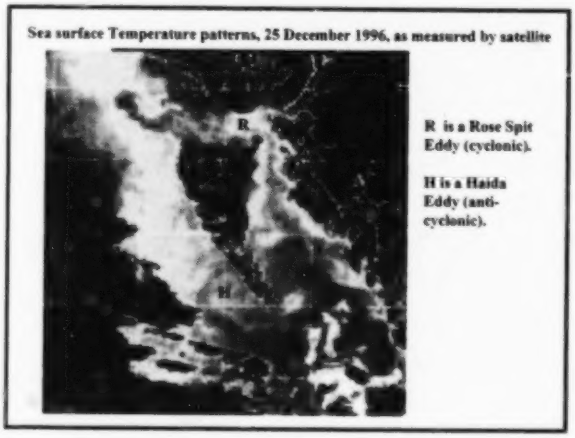
The Canadian-US border runs from headland to headland across northern Dixon Entrance.







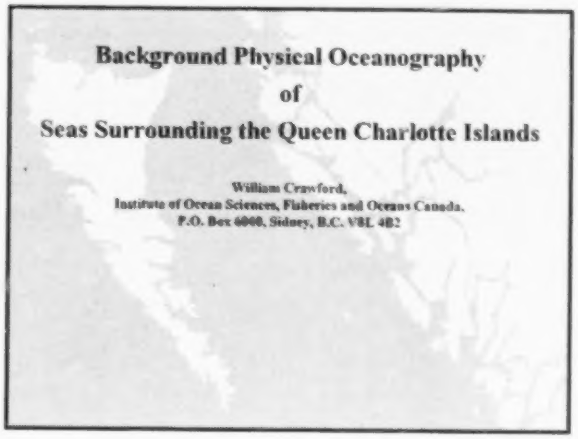
Sea surface Temperature patterns, 24 July 1994, as measured by satellite



Sea surface Temperature patterns, 25 December 1996, as measured by satellite

R is a Rose Spit Eddy (cyclonic).

H is a Haida Eddy (anti-cyclonic).



Background Physical Oceanography of Seas Surrounding the Queen Charlotte Islands

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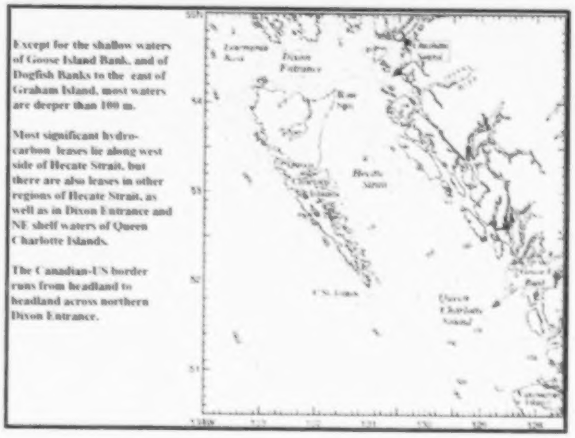

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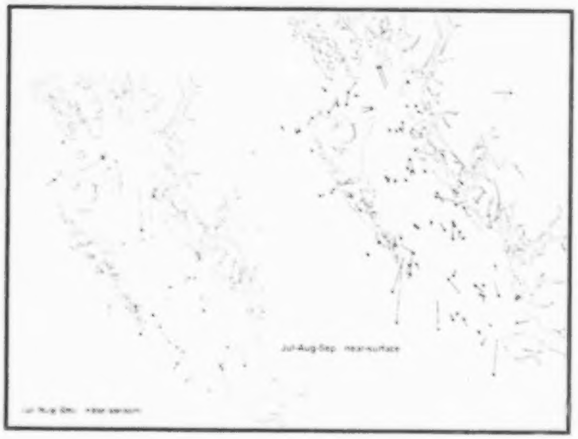

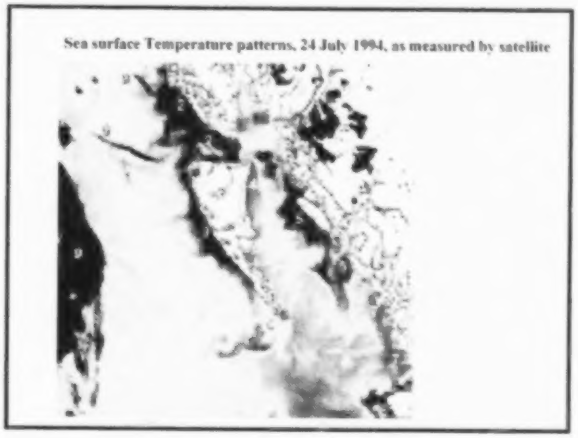

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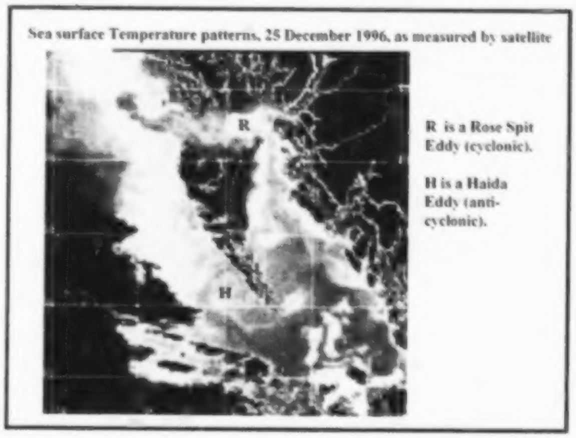

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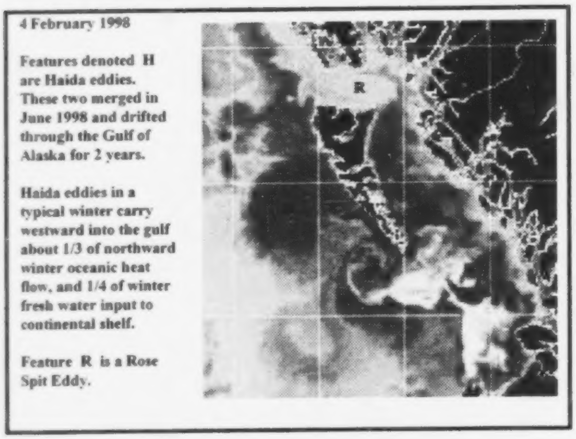
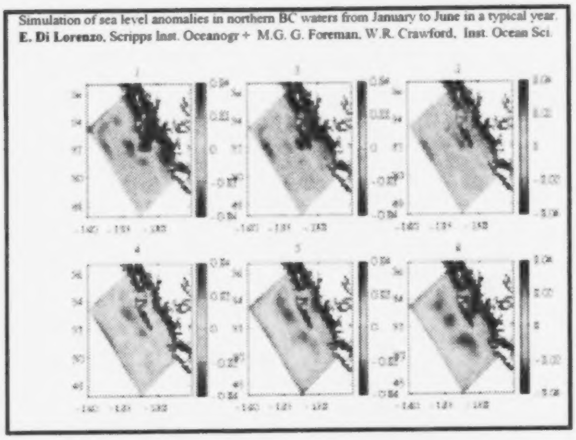


4 February 1998

Features denoted H are Haida eddies. These two merged in June 1998 and drifted through the Gulf of Alaska for 2 years.

Haida eddies in a typical winter carry westward into the gulf about 1/3 of northward winter oceanic heat flow, and 1/4 of winter fresh water input to continental shelf.

Feature R is a Rose Spit Eddy.



Simulation of sea level anomalies in northern BC waters from January to June in a typical year.
E. Di Lorenzo, Scripps Inst. Oceanogr + M.G. G. Foreman, W.R. Crawford, Inst. Ocean Sci.

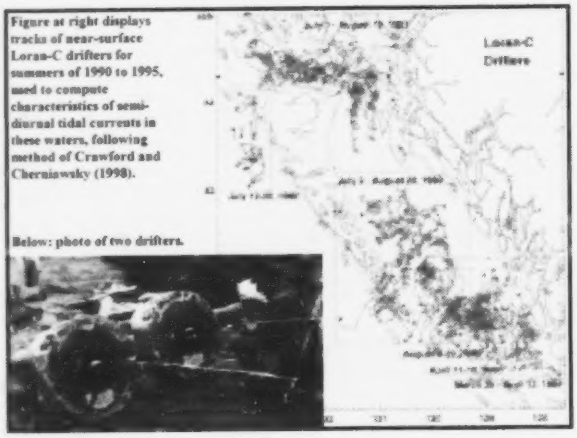
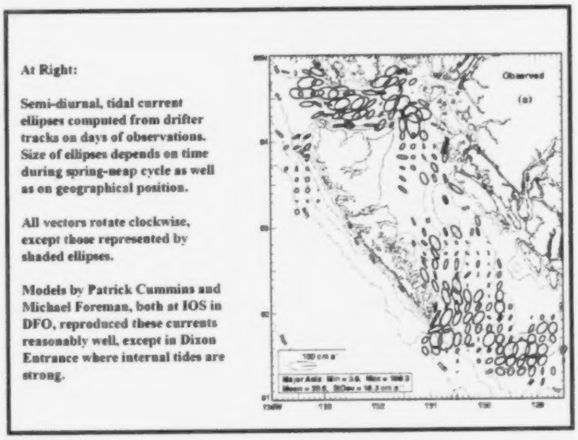


Figure at right displays tracks of near-surface Loran-C drifters for summers of 1990 to 1995, used to compute characteristics of semi-diurnal tidal currents in these waters, following method of Crawford and Cherniawsky (1998).

Below: photo of two drifters.

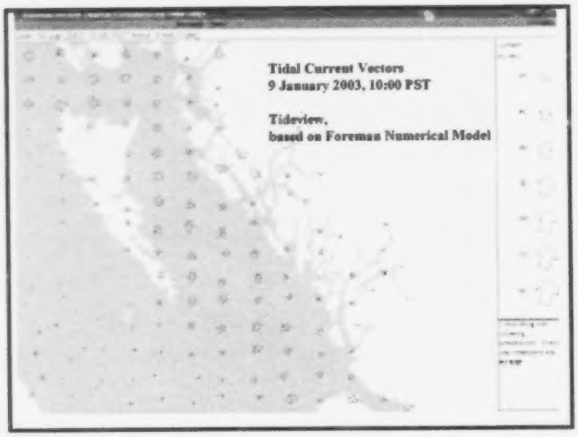


At Right:

Semi-diurnal, tidal current ellipses computed from drifter tracks on days of observations. Size of ellipses depends on time during spring-neap cycle as well as on geographical position.

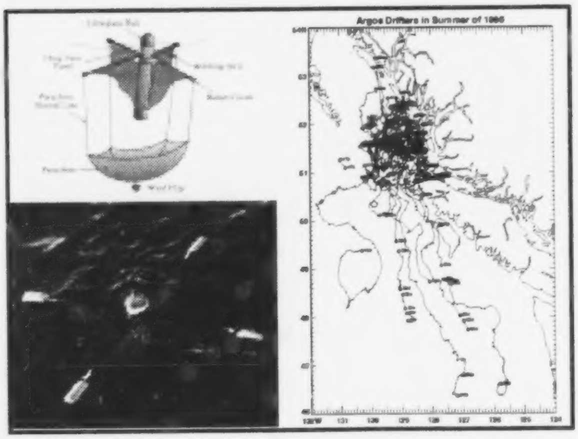
All vectors rotate clockwise, except those represented by shaded ellipses.

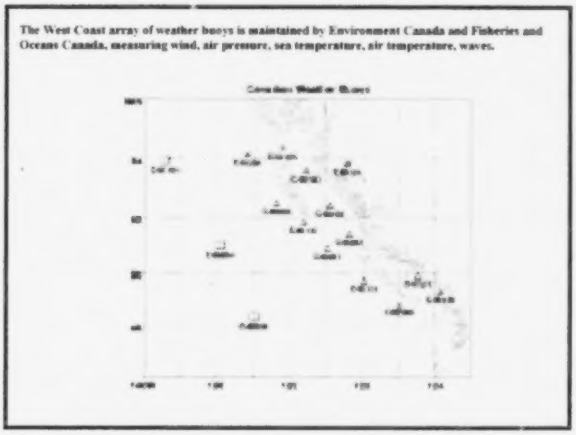
Models by Patrick Cummins and Michael Foreman, both at IOS in DFO, reproduced these currents reasonably well, except in Dixon Entrance where internal tides are strong.



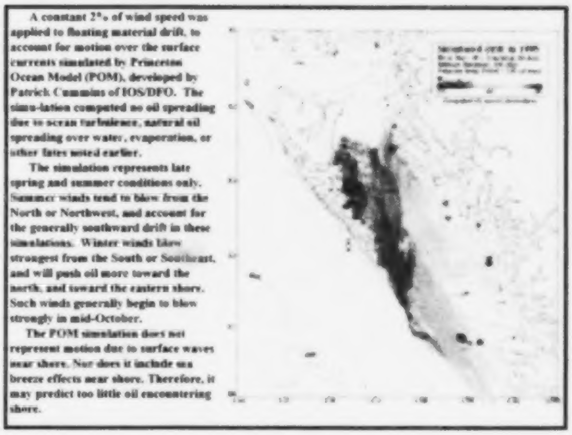
Tidal Current Vectors
9 January 2003, 10:00 PST

Tideview,
based on Foreman Numerical Model





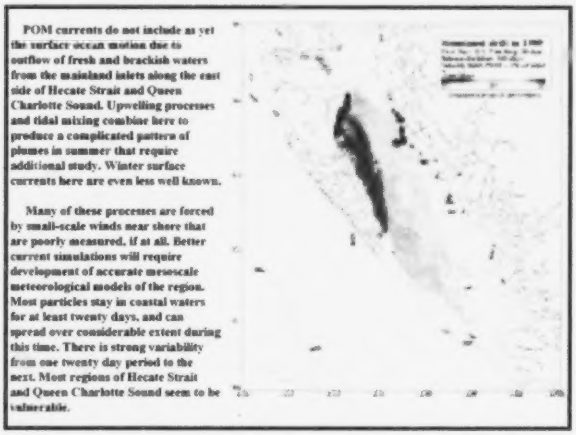
The West Coast array of weather buoys is maintained by Environment Canada and Fisheries and Oceans Canada, measuring wind, air pressure, sea temperature, air temperature, waves.



A constant 2% of wind speed was applied to floating material drift, to account for motion over the surface currents simulated by Princeton Ocean Model (POM), developed by Patrick Cummins of IOS/DFO. The simu-lation computed no oil spreading due to ocean turbulence, natural oil spreading over water, evaporation, or other fates noted earlier.

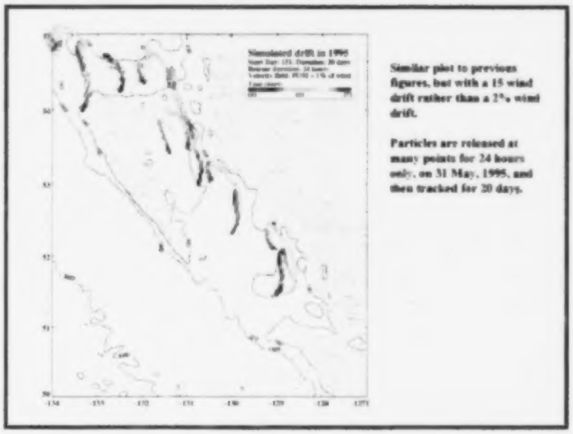
The simulation represents late spring and summer conditions only. Summer winds tend to blow from the North or Northwest, and account for the generally southward drift in these simulations. Winter winds blow strongest from the South or Southeast, and will push oil more toward the north, and toward the eastern shore. Such winds generally begin to blow strongly in mid-October.

The POM simulation does not represent motion due to surface waves near shore. Nor does it include sea breeze effects near shore. Therefore, it may predict too little oil encountering shore.



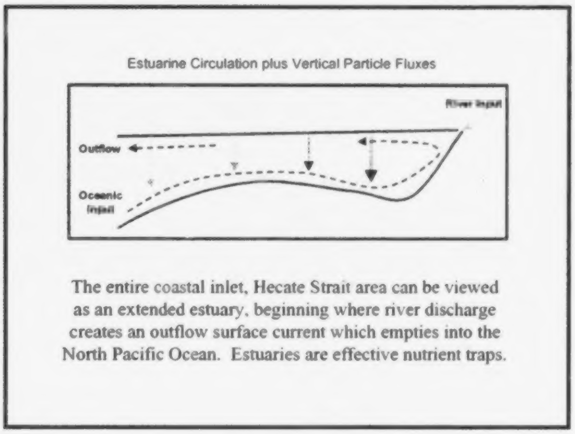
POM currents do not include as yet the surface ocean motion due to outflow of fresh and brackish waters from the mainland inlets along the east side of Hecate Strait and Queen Charlotte Sound. Upwelling processes and tidal mixing combine here to produce a complicated pattern of plumes in summer that require additional study. Winter surface currents here are even less well known.

Many of these processes are forced by small-scale winds near shore that are poorly measured, if at all. Better current simulations will require development of accurate mesoscale meteorological models of the region. Most particles stay in coastal waters for at least twenty days, and can spread over considerable extent during this time. There is strong variability from one twenty day period to the next. Most regions of Hecate Strait and Queen Charlotte Sound seem to be vulnerable.



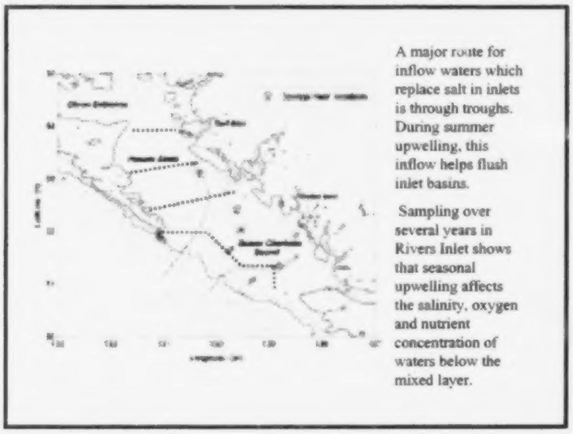
Similar plot to previous figures, but with a 1% wind drift rather than a 2% wind drift.

Particles are released at many points for 24 hours only, on 31 May, 1995, and then tracked for 20 days.



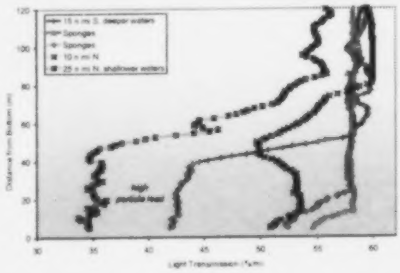
Estuarine Circulation plus Vertical Particle Fluxes

The entire coastal inlet, Hecate Strait area can be viewed as an extended estuary, beginning where river discharge creates an outflow surface current which empties into the North Pacific Ocean. Estuaries are effective nutrient traps.



A major route for inflow waters which replace salt in inlets is through troughs. During summer upwelling, this inflow helps flush inlet basins.

Sampling over several years in Rivers Inlet shows that seasonal upwelling affects the salinity, oxygen and nutrient concentration of waters below the mixed layer.



Sponge reefs occupy a very selective habitat in Hecate Strait and Queen Charlotte Sound. They require high silicate concentrations for their spicules and rocky bottom to grow on. A recent survey (summer 2002) suggest they are efficient particle trappers, growing on the mound of detritus that results. Some reef mounds are 30 m high.

RECOMMENDATIONS
Environmental Effects, physical oceanography and meteorology.

Adapted from manuscript:
Modelling Oceanic Fates of Oil, Drilling Muds and Produced Water from the Offshore Oil and Gas Industry, with Application to British Columbia, submitted to *Pacific Science Advisory Review Committee*, DFO, December 2002, by Crawford, Cretney, Cherniawsky, and Hannah.

Several numerical, hydrodynamical, ocean models have been applied to the Queen Charlotte Assessment Region, and evaluated with oceanographic observations. PERD funding for this program ceased in 1996. Faster computers and improved hydrodynamical models have been developed recently, and funding should be provided to apply these improvements to the Queen Charlotte Assessment Region. Upgrades will improve simulations of tidal currents, bottom currents, rate of exchange of water between basins, penetration of contaminants into inlets, channels and bays, and the potential of oil to sink below surface brackish water and penetrate into inlets below surface.

Additional observations are required to provide better model simulations of ocean currents and drift. A program to measure winter currents using surface drifters will help determine the penetration of oil-on-surface into inlets. Better measurement of mid-depth and bottom currents and sediment motion will help determine transport of produced water or drilling muds away from well heads, and toward sensitive habitat, fjords, and unique biological features such as sponge reefs.

Since completion of the PERD-funded field program in 1996, there have been major inter-annual changes in seawater properties in the northeast Pacific Ocean, that appear to have impacted fish stocks in the Queen Charlotte Assessment Region, but these changes of seawater characteristics, such as temperature, nutrient composition, and ocean currents, were poorly measured in these local waters.

Funding should be provided for an ongoing program to determine inter-annual changes in the seawater properties of the Queen Charlotte Assessment Region, and their impact on the ecology and fish stocks. Without such research, it will be difficult to distinguish changes in ecology due to contaminants from changes due to climate variability and change.

These changes in climate may have impacted wave climate as well. (More on this from Diane Masson next.)

Accurate wind measurements and forecasts are essential for spill prediction and risk assessment. The present set of Canadian Weather Buoys on the Pacific Coast should be considered a minimum number for data input to oil spill models and for evaluation of regions-at-risk.

Canadian Weather Buoys measure winds in mid-strait, and do not provide needed information on near-shore winds that will influence adhesion of oil on the beaches, or into inlets and narrow channels. Real-time winds as measured at Canadian Weather Buoys and forecast winds based on regional, high resolution models must be available to assess potential oil spill motion and hence vulnerability of sensitive regions.

Environmental Factors
Present models under-report tidal currents and extreme non-tidal currents. Additional effort will be needed to determine ocean currents for engineering applications, and to develop operational models of currents. Existing numerical models of tidal heights in these waters are accurate. Additional work may be needed to predict non-tidal sea level changes. Waves will be discussed by Diane Masson next.

Discussion

Near bottom current measurements are based on a standard measurement of 15 m off the bottom. If information on currents 2 m off the bottom is required, it is uncertain how relevant these measurements would be. A published paper by Crawford shows the strongest bottom current vector measured at each site. Shipboard ADCP is useful but there is a need to unscramble the tidal and non-tidal currents. The disadvantage is that it takes work to get it into a useable form.

El Niño is a winter phenomenon that really changes winter currents but only in years of very strong El Niño. Significant events on the West Coast took place in 1982, 1983, 1997 and 1998. Alterations in productivity are caused by El Niño induced changes in water masses but there are other causes as well. The late 1990s were poor years for biological productivity on the shelf even in those years that were not El Niño years.

On the East Coast, current measurements on the slope were important, as this was one of the primary areas for exploration. Few measurements have been taken on the West Coast slope. There are measurements at three points on the slope along the West Coast of the Queen Charlotte Islands. These measurements showed internal tides. On the West Coast, there is concern about locating moorings on the slope because it is steep.

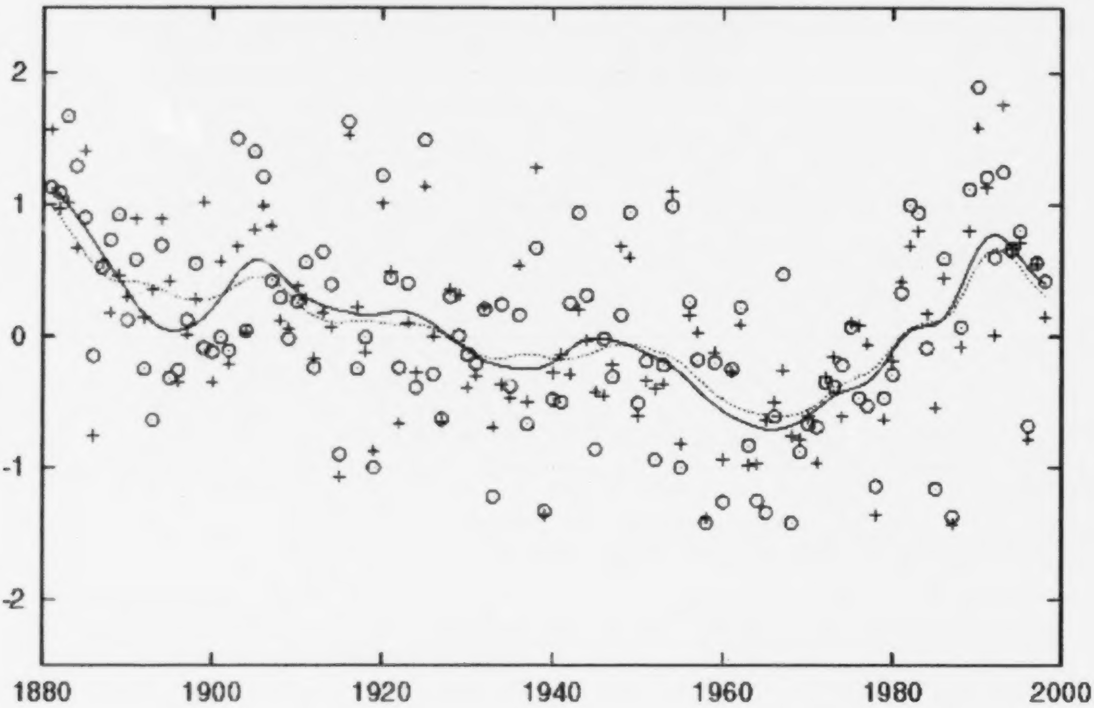
West Coast Offshore Oil and Gas Workshop: PERD

West Coast Waves

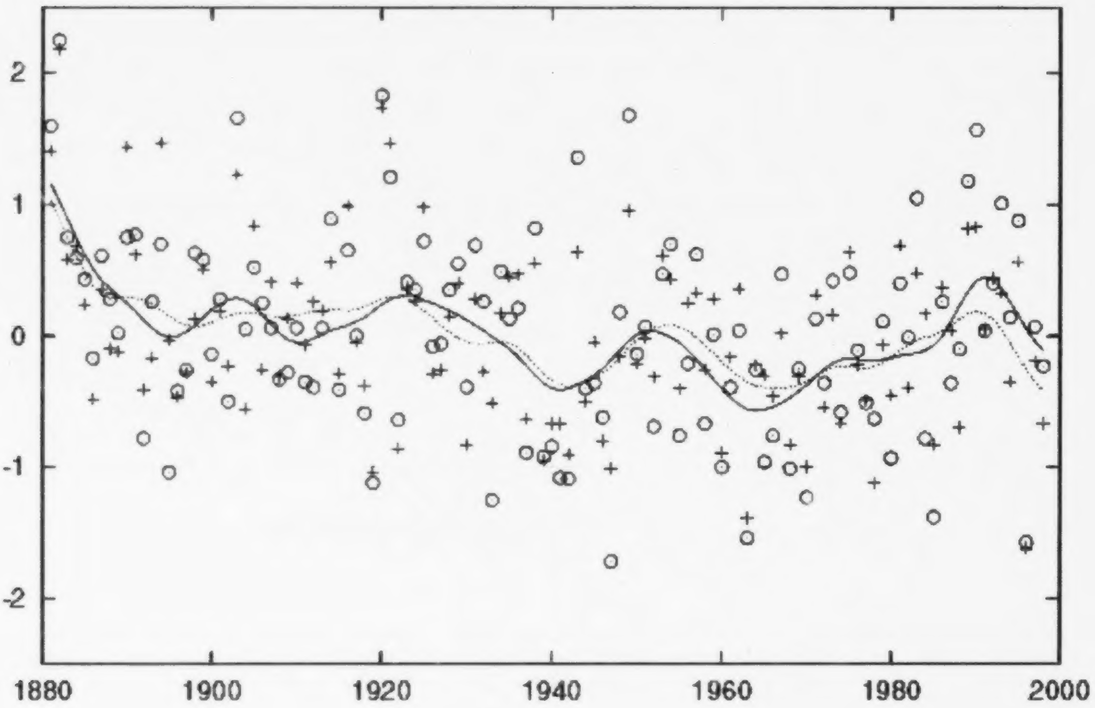
D. Masson

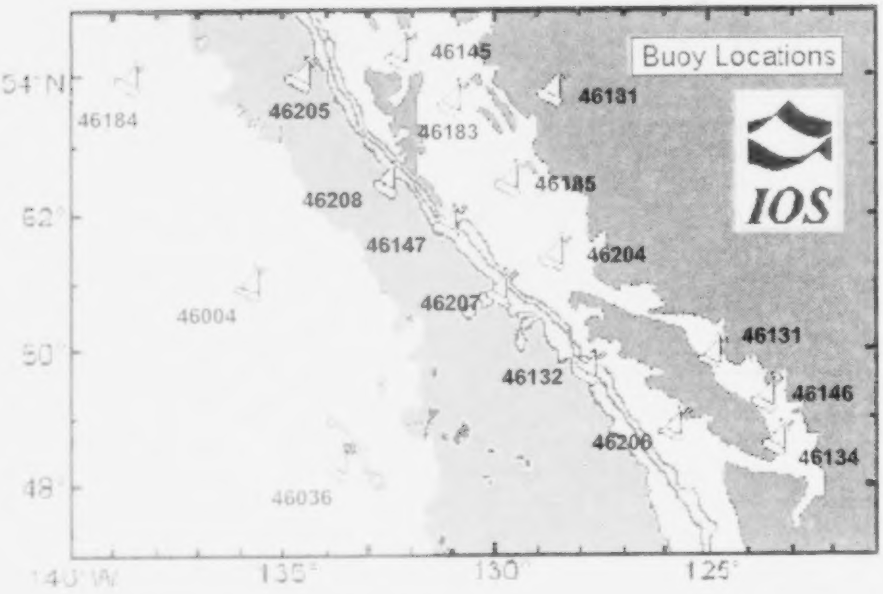
Fisheries and Oceans Canada

British Isles, North Sea, Norwegian Sea, 1881-1998



Scandinavia, Finland, Baltic Sea, 1881-1998





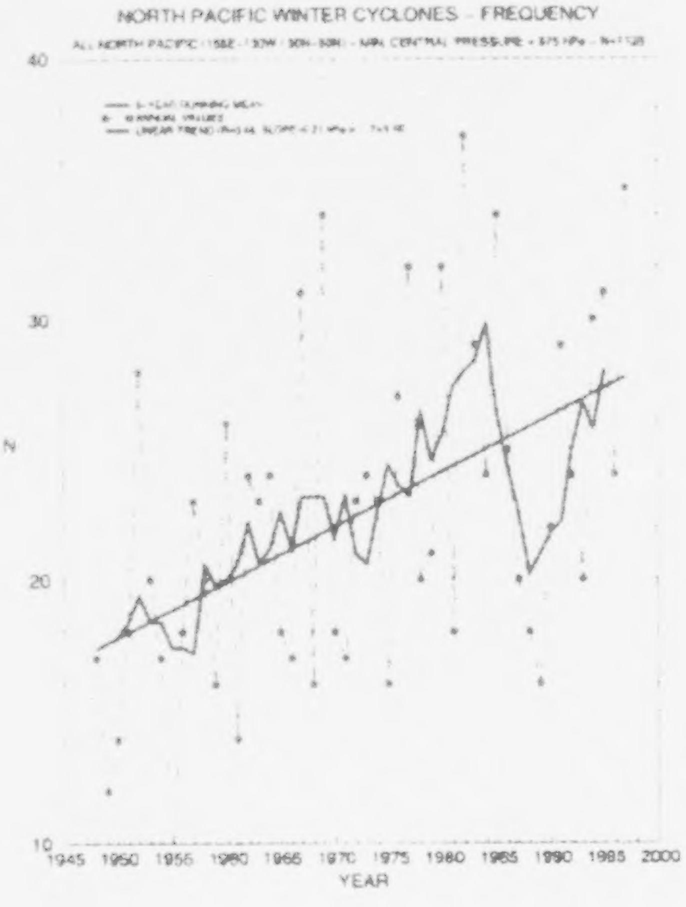
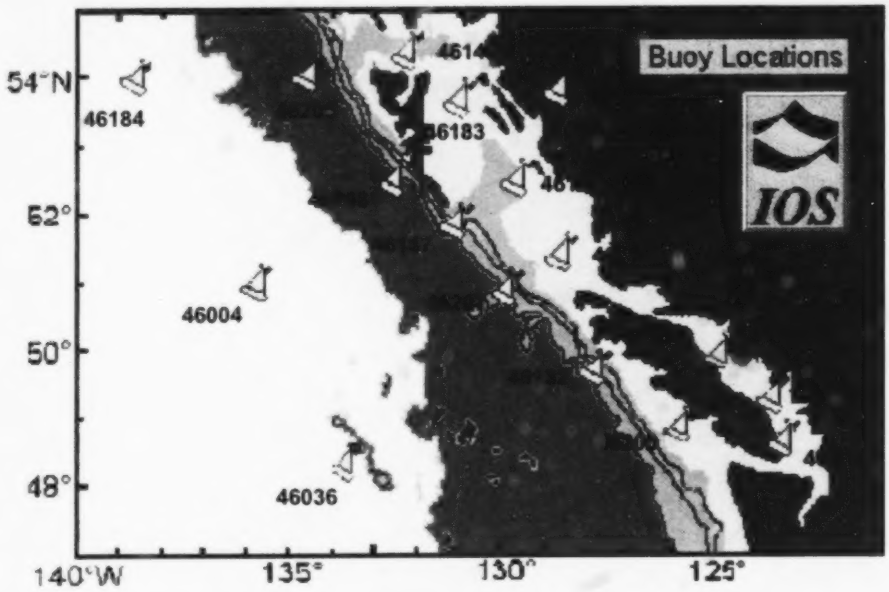
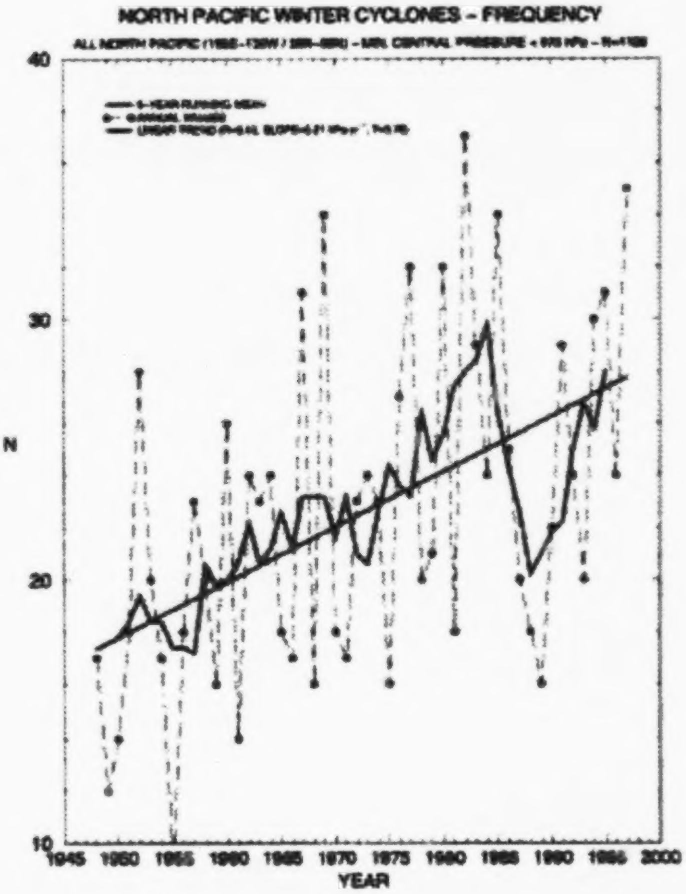


Fig 2 (a) Time series of winter (Dec-Mar) counts of North Pacific cyclones with minimum central pressure less than 975 hPa. The curves show the raw data (dashed line with circles), the 5-yr running average (heavy solid line) and the linear trend.





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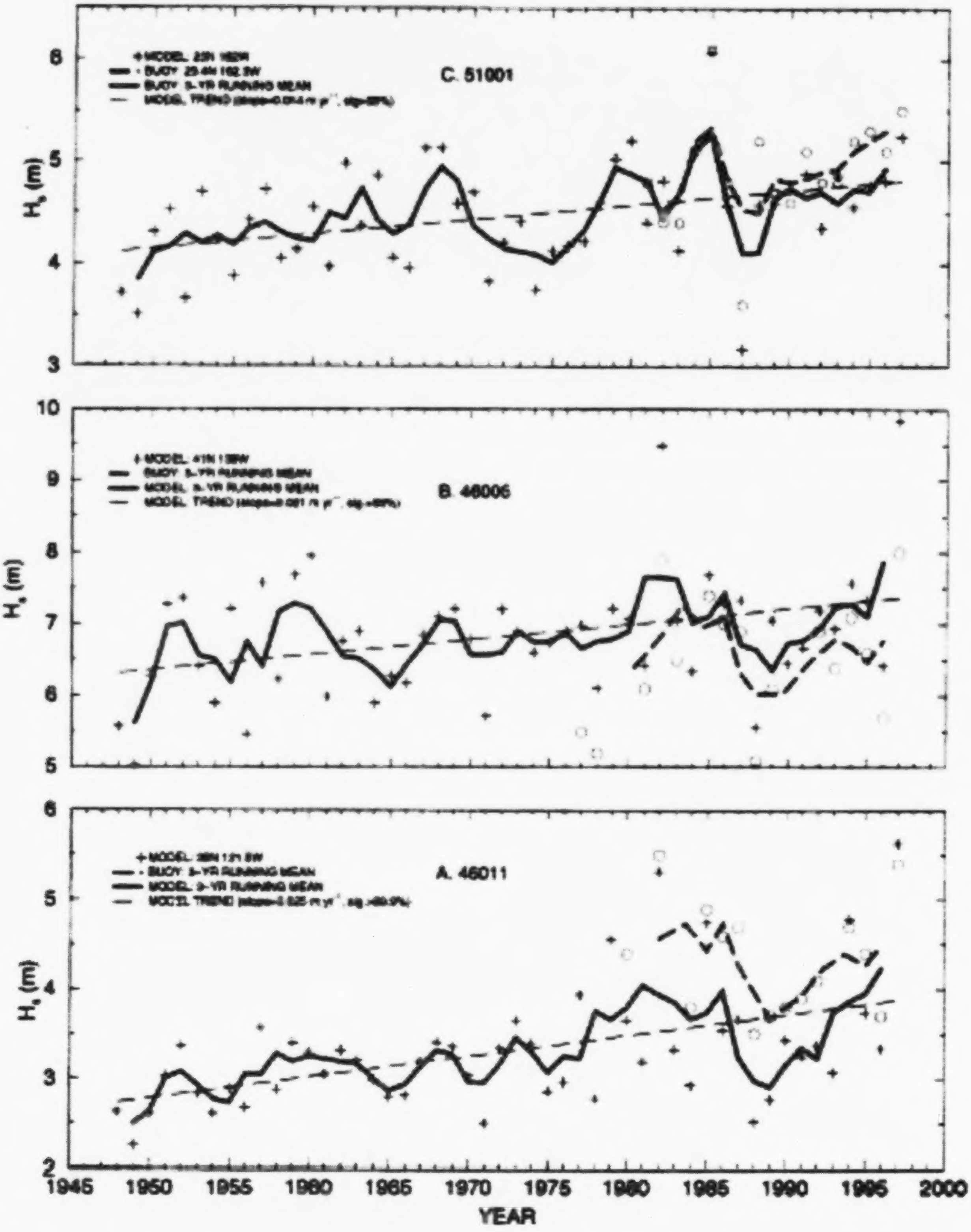

C. 51001
MODEL 23N 162W
BUOY 23.4N 162.3W
BUOY 3-YR RUNNING MEAN
MODEL TREND (slope=0.014 m yr⁻¹, sig>
B. 46006
MODEL 41N 138W
BUOY 3-YR RUNNING MEAN
MODEL 3-YR RUNNING MEAN
MODEL TREND (slope=0.021 m yr⁻¹, sig >
A. 46011
MODEL 35N 121.5W
BUOY 3-YR RUNNING MEAN
MODEL 3-YR RUNNING MEAN
MODEL TREND (slope=0.025 m yr⁻¹, sig >99.9%)
Hs (m)
3
4
5
6
5
6
7
8
9
10
2
3
4
5
6
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
YEAR

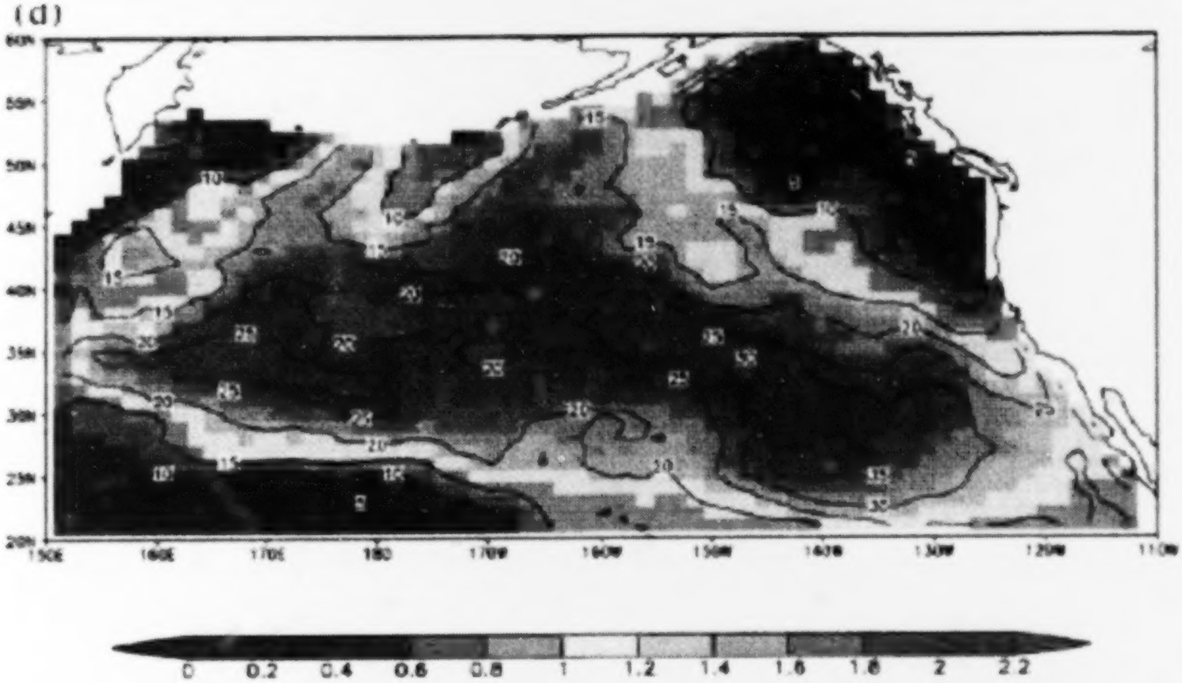


Fig. 11. Dec-Mar 95th percentile significant wave heights for NOAA buoys (a) 46011, (b) 46006, and (c) 51001; heavy solid and dashed lines are 3-yr running averages from hindcast and measured data, respectively; symbols are unsmoothed values; thin dashed lines show linear trends in hindcast data. For years with observations, the plotted data are for contemporaneous 3-hourly data. Buoy 46011 is located at 34.9°N, 120.9 °W; the model grid point is at 35 °N,120 °W. Buoy 46006 is located at 40.9 °N, 137.5 °W; model data grid point is at 41 °N, 138 °W; Buoy 51001 is located at 23.4N, 162.3 ° W; model data grid point is at 23 °N, 162 °W. See Fig. 12a for locations. (d) Trends in hindcast Dec-Mar 99th percentile H_s [m(50yr)$^{-1}$]. Black contour lines show trend expressed as a fraction of the long-term mean.

Discussion

It is important to design a wave climate study with as long a sampling period as possible. Earlier determinations of maximum wave height were not based on the correct wave buoy algorithm. Also, computation of the maximum wave was wrong: calculating the maximum wave as twice the maximum positive amplitude, rather than true peak to trough.

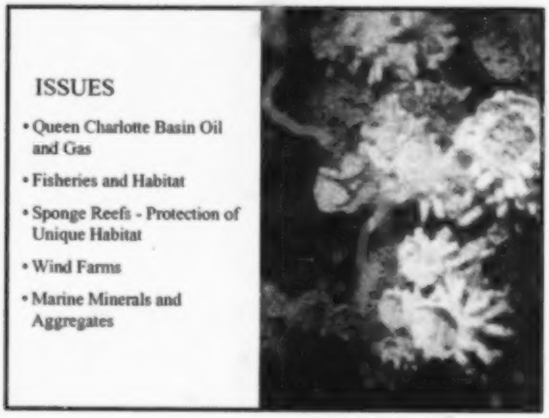
A Pacific study using the Wave Watch 3 Model off California was shown to give poor results for the total wave condition because it was tuned to emphasise swell. There is a recent study on the Northern Hemisphere with both a Pacific component and an Atlantic component that also has a subsequent Atlantic component based on hind cast. These two studies are relevant to the West Coast.

The 1992 maximum 100-year wave within Hecate Strait and Queen Charlotte Sound was 25 m, but this does not include the shallow water effect so there is a margin of error.

An Overview of West Coast Marine Geoscience

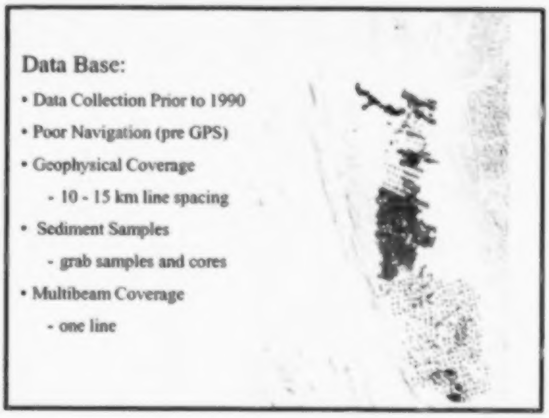
V. Barrie

Natural Resources Canada



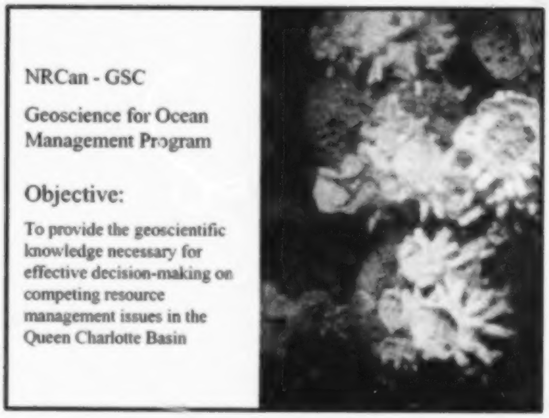
ISSUES

- Queen Charlotte Basin Oil and Gas
- Fisheries and Habitat
- Sponge Reefs - Protection of Unique Habitat
- Wind Farms
- Marine Minerals and Aggregates



Data Base:

- Data Collection Prior to 1990
- Poor Navigation (pre GPS)
- Geophysical Coverage
  - 10 - 15 km line spacing
- Sediment Samples
  - grab samples and cores
- Multibeam Coverage
  - one line

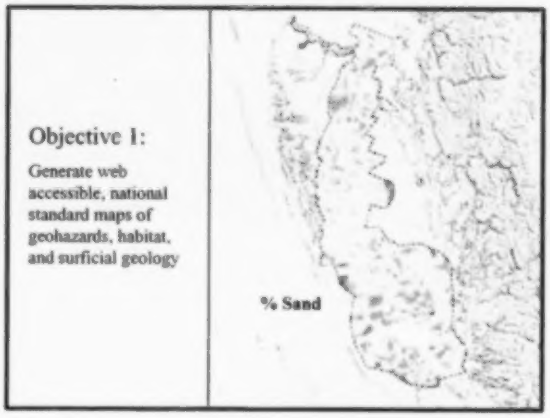


NRCan - GSC

Geoscience for Ocean Management Program

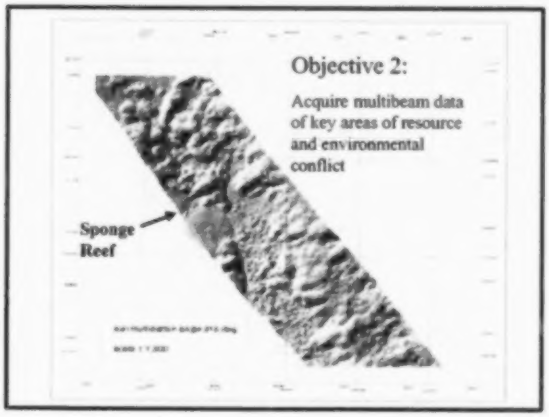
Objective:

To provide the geoscientific knowledge necessary for effective decision-making on competing resource management issues in the Queen Charlotte Basin



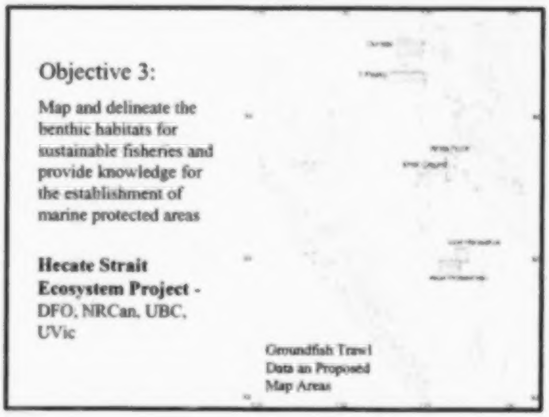
Objective 1:

Generate web accessible, national standard maps of geohazards, habitat, and surficial geology



Objective 2:

Acquire multibeam data of key areas of resource and environmental conflict

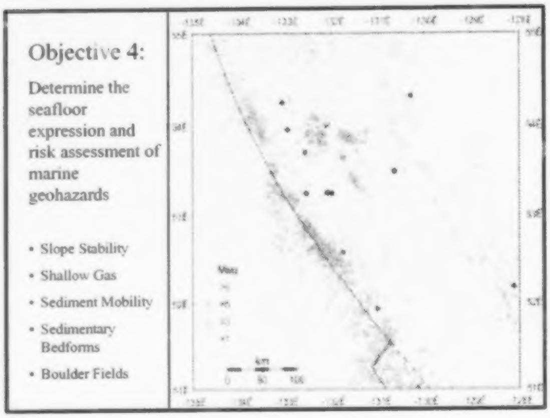


Objective 3:

Map and delineate the benthic habitats for sustainable fisheries and provide knowledge for the establishment of marine protected areas

Hecate Strait Ecosystem Project - DFO, NRCan, UBC, UVic

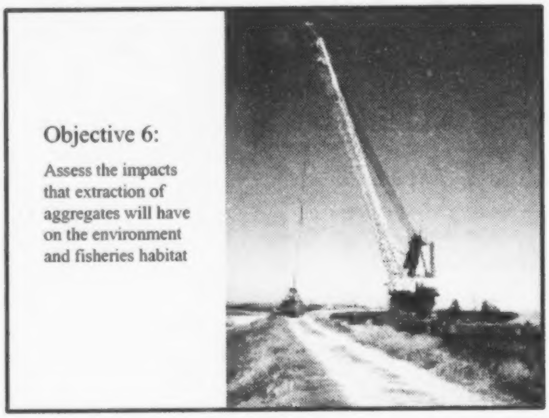
Groundfish Trawl Data an Proposed Map Areas



Objective 4:

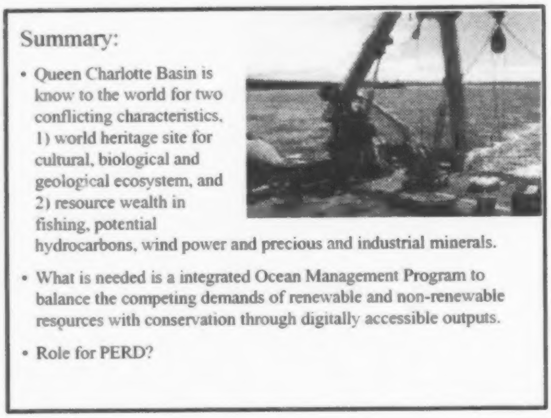
Determine the seafloor expression and risk assessment of marine geohazards

- Slope Stability
- Shallow Gas
- Sediment Mobility
- Sedimentary Bedforms
- Boulder Fields



Objective 6:

Assess the impacts that extraction of aggregates will have on the environment and fisheries habitat



Summary:

- Queen Charlotte Basin is know to the world for two conflicting characteristics, 1) world heritage site for cultural, biological and geological ecosystem, and 2) resource wealth in fishing, potential hydrocarbons, wind power and precious and industrial minerals.
- What is needed is a integrated Ocean Management Program to balance the competing demands of renewable and non-renewable resources with conservation through digitally accessible outputs.
- Role for PERD?

Discussion

The 70% referred to in the presentation is based on the area mapped. If a multibeam survey program goes ahead, it will delineate the boundaries of features.

Earthquakes and Earthquake Hazard in the Queen Charlotte Islands Region

G. Rogers
Natural Resources Canada

Earthquakes and Earthquake Hazard in the Queen Charlotte Islands Region

Garry Rogers
Natural Resources Canada
Geological Survey of Canada
Pacific Geoscience Centre
Sidney, B.C. V8L 4B2

INTRODUCTION

The Queen Charlotte Islands region has a high rate of earthquake activity. The Queen Charlotte fault, which runs along the west coast of the Islands, is one of the world's major tectonic plate boundaries. Like the San Andreas fault in California, it accommodates motion between the Pacific plate and the North American plate. Canada's largest historic earthquake, a magnitude 8.1 event in 1949, occurred along this fault. It is a feature that has ongoing earthquake activity and people in the region feel earthquakes regularly. There was much concern expressed about earthquake hazard during the West Coast Offshore Environmental Review Panel hearings in 1983

PREVIOUS OERD PROJECT IN THE REGION

From the mid 1980s to mid 1990s OERD funded the operation of a seismograph network in the Queen Charlotte Island region. This snapshot of earthquake activity at a lower magnitude threshold revealed a more extensive seismicity pattern than that associated directly with the Queen Charlotte fault. In particular, considerable earthquake activity occurs east of the fault, on Graham Island and in Hecate Strait. A magnitude 5.3 earthquake occurred in Hecate Strait in 1990. None of the earthquake activity appears to be associated with mapped faults. Focal mechanism studies reveal that the earthquakes are occurring on a wide range of fault orientations, but are being activated by a consistent north-northeast compressional stress field.

The network also revealed that most of the earthquake activity in the vicinity of the Queen Charlotte fault, is not on the fault itself, but in a band of activity on either side of the fault. The earthquake rate is also not uniform along the fault, with some areas having much higher activity than others.

EARTHQUAKE HAZARD ASSESSMENT

An earthquake hazard assessment for the region exists in the form of national earthquake hazard maps that are part of the National Building Code of Canada. The Geological Survey of Canada is responsible for producing these maps. The main tool used in producing the hazard maps is the statistical analysis of past earthquake activity. The basic assumption in applying the statistical analysis is that earthquake occurrence is a random process that is constant though time. In assessing hazard in the vicinity of a major plate boundary this assumption breaks down because of the varying rate of activity in between very large earthquakes. Other techniques such as crustal deformation measurements or paleoseismic investigations are required to get a robust assessment of the earthquake hazard.

UNSOLVED PROBLEMS

There is a need to determine where and when large earthquakes are likely to occur in this region, to calculate the expected level and duration of shaking, and to determine if and where local tsunamis may be generated.

The present motion between the Pacific and North American plates is not currently parallel to the Queen Charlotte fault. How the component of plate motion perpendicular to the fault is accommodated is not clear. In 2001 a magnitude 6.3 pure thrust earthquake occurred in the vicinity of the Queen Charlotte fault, generating a small tsunami. Whether this tectonic setting can produce large megathrust earthquakes and accompanying large tsunamis is a subject that needs investigation. Initial GPS measurements in the region show significant strain rates but are not yet dense enough to resolve the accumulating strain field.

ADDRESSING THE UNSOLVED PROBLEMS

What is required to arrive at a robust estimate of earthquake hazard in the Queen Charlotte Islands region is to gather the new data necessary to make the estimate. This would involve supplementing the current seismic network in the region, making it similar to the OERD funded network that operated from the mid 1980s to the mid 1990s. In addition, deploying a modern GPS network would allow the necessary crustal strain measurements for earthquake hazard assessment to be made. A minimum of 3 years of GPS monitoring is required to assess the nature of crustal strain.

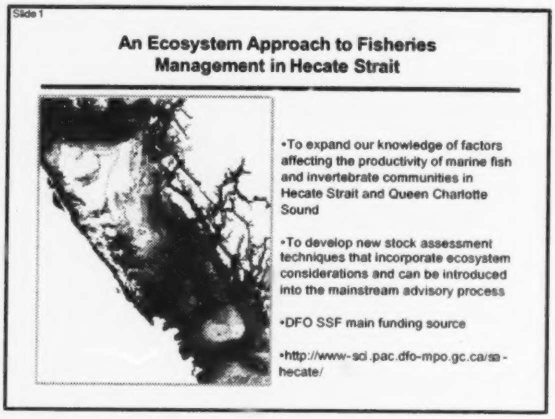
Discussion

While the risks associated with floating platforms are less than with fixed platforms, risks still exist. Risk is associated with blowouts, pipeline ruptures and the associated structures or infrastructure used to exploit the resource. There are standards in the world for fixed and floating platforms. The Canadian Standards Association has a specific document to deal with fixed structures. Along with development comes a whole range of physical structures (e.g., a gas pipeline in the Queen Charlotte Islands where not a lot of data exist).

In regards to the costs of re-installing and maintaining a network to collect seismic data; once the system is installed the annual cost is a few ten thousand dollars plus the cost of analysis. The capital cost for the GPS sites is $50-60K per installation. The seismic data comes out via satellite link. One satellite link in the Queen Charlottes costs about $5K per year plus some cost to service the equipment. Depending on how quickly one proceeds to expand the system, the costs ranges from a few hundred thousand dollars, plus ongoing expenses, plus some people, which increases the cost to $800K, including people for analysis work if it were done in two years. The existing system uses partnerships; for example, the local school board provides Internet access, the Coast Guard provides free sites and facilities and helicopter support and the University provides graduate students.

An Ecosystem Approach to Fisheries Management in Hecate Strait

A. Sinclair
Fisheries and Oceans Canada



Slide 1

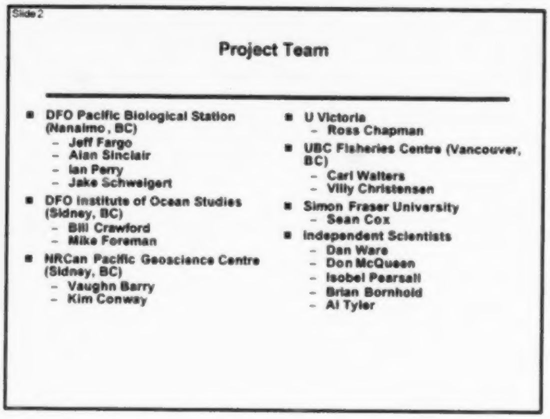
An Ecosystem Approach to Fisheries Management in Hecate Strait

•To expand our knowledge of factors affecting the productivity of marine fish and invertebrate communities in Hecate Strait and Queen Charlotte Sound

•To develop new stock assessment techniques that incorporate ecosystem considerations and can be introduced into the mainstream advisory process

•DFO SSF main funding source

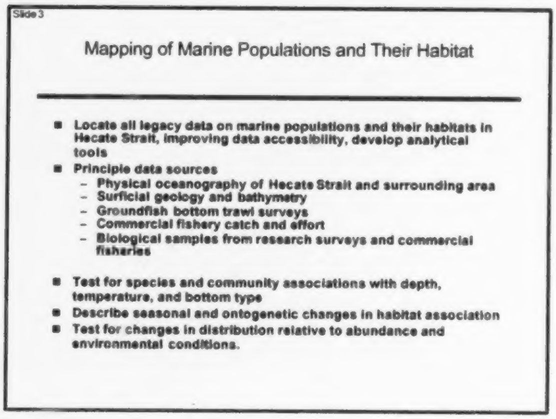
•http://www-sci.pac.dfo-mpo.gc.ca/sa-hecate/



Slide 2

Project Team

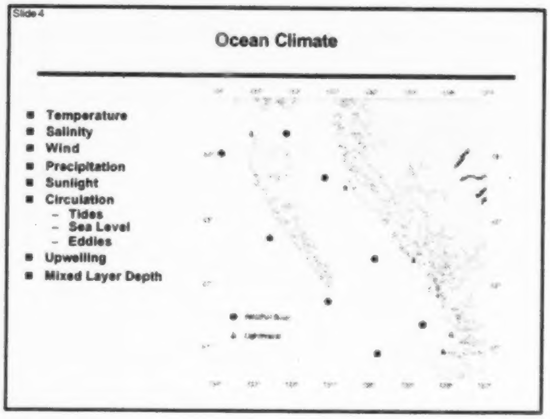
- **DFO Pacific Biological Station (Nanaimo, BC)**
  - **Jeff Fargo**
  - **Alan Sinclair**
  - **Ian Perry**
  - **Jake Schweigert**
- **DFO Institute of Ocean Studies (Sidney, BC)**
  - **Bill Crawford**
  - **Mike Foreman**
- **NRCan Pacific Geoscience Centre (Sidney, BC)**
  - **Vaughn Barry**
  - **Kim Conway**
- **U Victoria**
  - **Ross Chapman**
- **UBC Fisheries Centre (Vancouver, BC)**
  - **Carl Walters**
  - **Villy Christensen**
- **Simon Fraser University**
  - **Sean Cox**
- **Independent Scientists**
  - **Dan Ware**
  - **Don McQueen**
  - **Isobel Pearsall**
  - **Brian Bornhold**
  - **Al Tyler**



Slide 3

Mapping of Marine Populations and Their Habitat

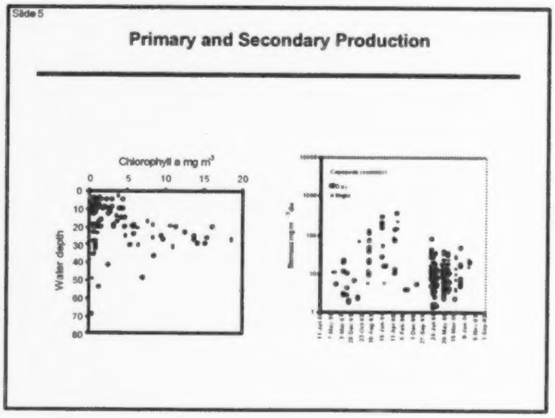
- **Locate all legacy data on marine populations and their habitats in Hecate Strait, improving data accessibility, develop analytical tools**
- **Principle data sources**
  - **Physical oceanography of Hecate Strait and surrounding area**
  - **Surficial geology and bathymetry**
  - **Groundfish bottom trawl surveys**
  - **Commercial fishery catch and effort**
  - **Biological samples from research surveys and commercial fisheries**
- **Test for species and community associations with depth, temperature, and bottom type**
- **Describe seasonal and ontogenetic changes in habitat association**
- **Test for changes in distribution relative to abundance and environmental conditions.**



Slide 4

Ocean Climate

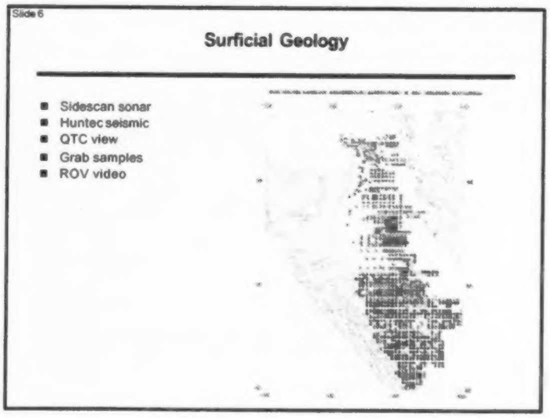
- **Temperature**
- **Salinity**
- **Wind**
- **Precipitation**
- **Sunlight**
- **Circulation**
  - **Tides**
  - **Sea Level**
  - **Eddies**
- **Upwelling**
- **Mixed Layer Depth**



Slide 5

Primary and Secondary Production

Chlorophyll a mg m3
0
5
10
15
20
Water depth
0
10
20
30
40
50
60
70
80
10000
1000
100
10
1



Slide 6

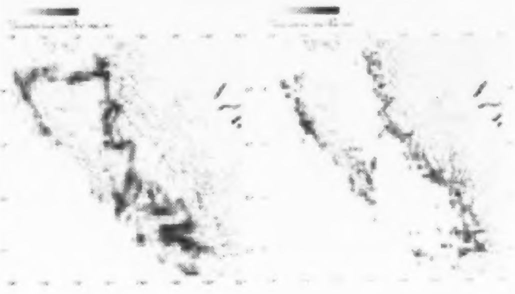
Surficial Geology

- Sidescan sonar
- Huntec seismic
- QTC view
- Grab samples
- ROV video

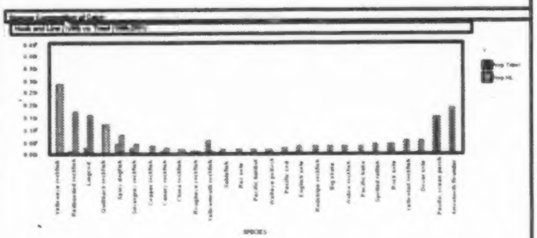
Fish and Invertebrate Populations

- **Fisheries**
- **Species distributions**
- **Diversity**
- **Marine communities**

Distribution of Trawl and Hook / Line Fisheries

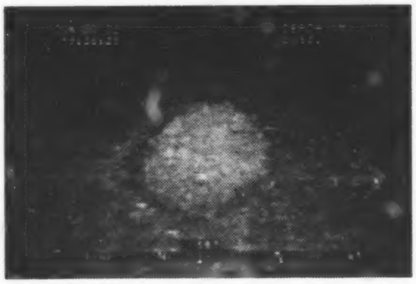


Species Composition of Trawl and Hook / Line Catches



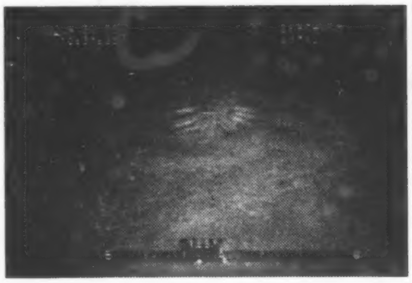
Hook and Line Habitat

- Rocky and bolder substrate
- Epifauna plentiful and diverse
- Common fish species are rockfish

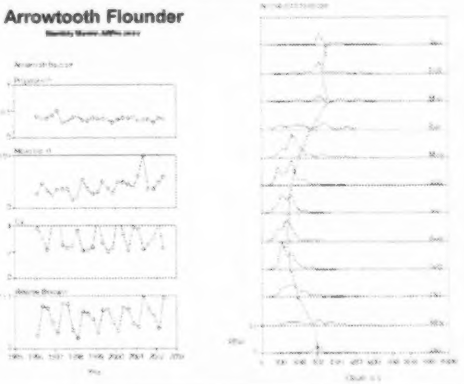


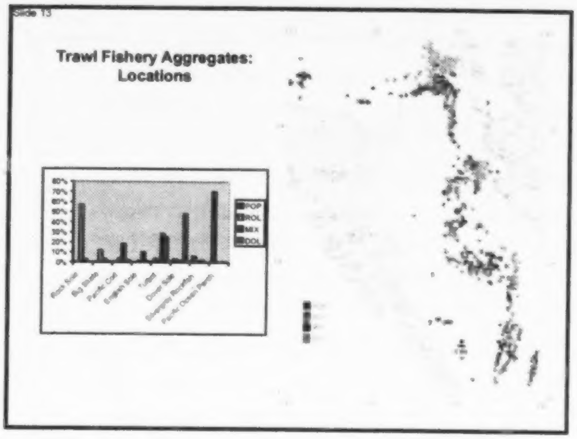
Trawl Habitat

- Substrate smooth sand and mud
- Limited epifaunal diversity
- Common fish species flatfish and gadoids

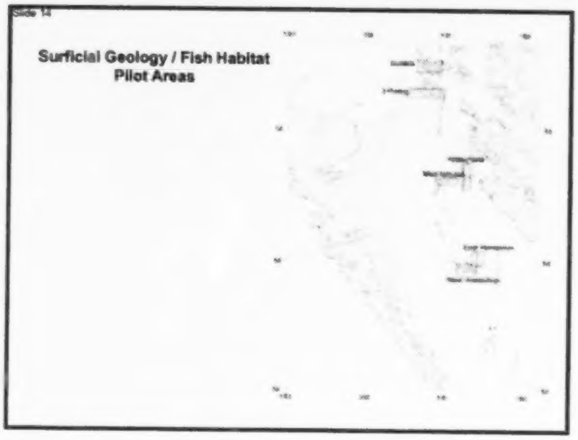


Arrowtooth Flounder

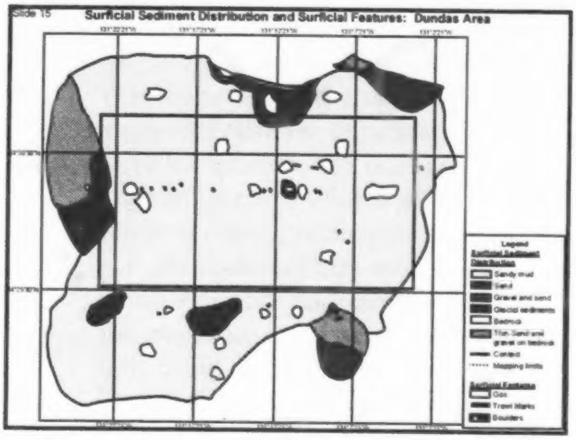




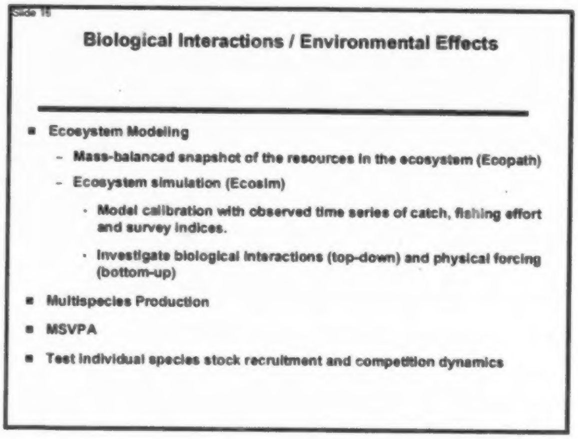
Trawl Fishery Aggregates: Locations



Surficial Geology / Fish Habitat Pilot Areas

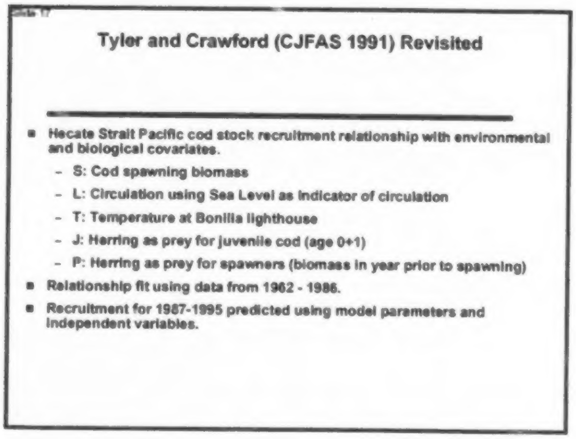


Surficial Sediment Distribution and Surficial Features: Dundas Area



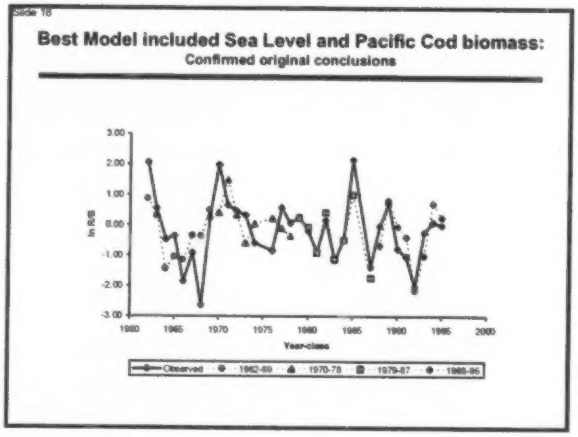
Biological Interactions / Environmental Effects

- Ecosystem Modeling
  - Mass-balanced snapshot of the resources in the ecosystem (Ecopath)
  - Ecosystem simulation (Ecosim)
    - Model calibration with observed time series of catch, fishing effort and survey indices.
    - Investigate biological interactions (top-down) and physical forcing (bottom-up)
- Multispecies Production
- MSVPA
- Test individual species stock recruitment and competition dynamics



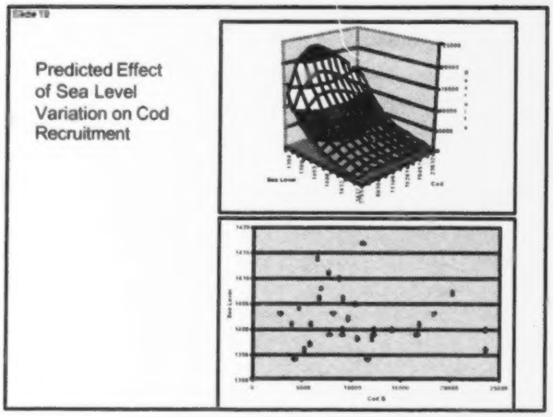
Tyler and Crawford (CJFAS 1991) Revisited

- Hecate Strait Pacific cod stock recruitment relationship with environmental and biological covariates.
  - S: Cod spawning biomass
  - L: Circulation using Sea Level as indicator of circulation
  - T: Temperature at Bonilla lighthouse
  - J: Herring as prey for juvenile cod (age 0+1)
  - P: Herring as prey for spawners (biomass in year prior to spawning)
- Relationship fit using data from 1962 - 1986.
- Recruitment for 1987-1995 predicted using model parameters and independent variables.



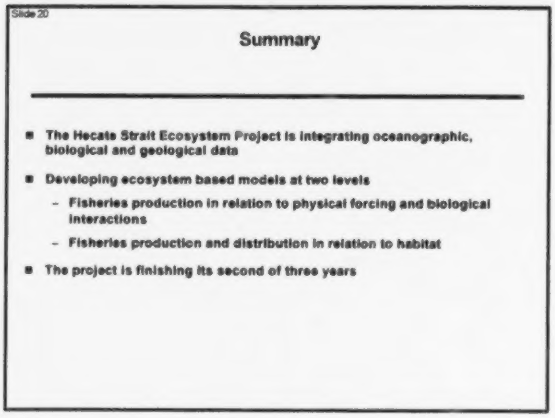
Best Model included Sea Level and Pacific Cod biomass:

Confirmed original conclusions



Slide 19

Predicted Effect of Sea Level Variation on Cod Recruitment



Slide 20

Summary

- The Hecate Strait Ecosystem Project is integrating oceanographic, biological and geological data
- Developing ecosystem based models at two levels
  - Fisheries production in relation to physical forcing and biological interactions
  - Fisheries production and distribution in relation to habitat
- The project is finishing its second of three years

Discussion

All of the observers have been on trawlers. The hook and line data comes from the fishing logbooks. Observers are being deployed on hook and line boats now but at a very low level, about 5%. They are much smaller vessels and harder to get people aboard. The bycatch of 200 species has been from trawlers, the numbers are much lower in the hook and line fishery. Previously, observers were deployed on trawl fleets, and about 80 species were reported. Now with observers to record bycatch and discards, the number is about 200. Discards would account for about 120 species.

In terms of sponge reefs, starting in 1999, observers began to record the occurrence of reef material in the nets so the information is in the observer data. Data agree well with known reef locations. The amount of fishing effort over reefs is very low; the reef material clutters up the nets. In 1999, there was a voluntary closure on the part of the trawl fishery to avoid fishing in the area designated as having living sponge reefs and there was an effort to avoid them. There was evidence from our trip in June that there had been some recent fishing over the reefs so there is now a regulated closure for trawlers.

Modelling that associates fish distribution and habitat has some obvious links to oil and gas development, transportation and decisions on where to site infrastructure. Rockfish populations along reefs live for something like 50 to 100 years. Rockfish, which are susceptible to fishing, have low productivity rates and are susceptible to oil spills, so there is interest in gaining more knowledge about what is going on in those areas. Ecosystem modelling is oriented towards physical forcing factors, such as temperature, that affect primary production. How to introduce perturbations that may stem from oil and gas development is not entirely clear. There are a few animals that are very important in the food chain about which we know very little. For example, the sandlance is the most important fish species in the diet of certain other fish, yet we know very little about its distribution and basic biology other than that it spends time burrowing in the sand. The sandlance could be sensitive to seismic exploration and various other activities. It would be important to devote time to this and the work would also contribute to delineating sensitive areas.

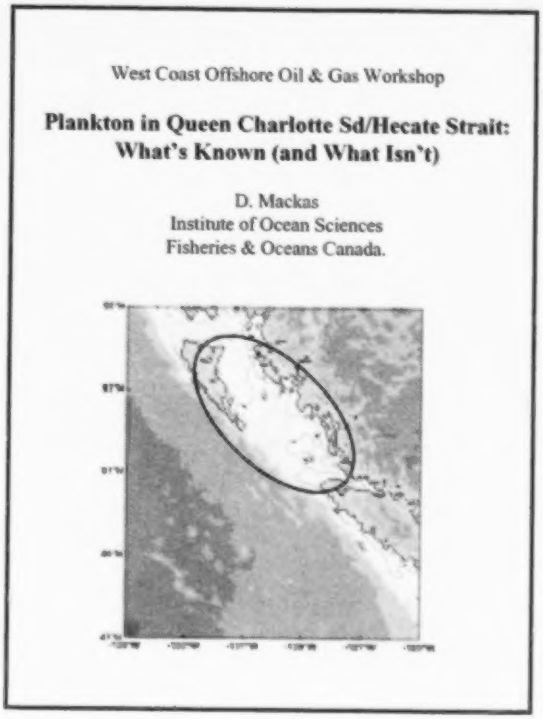
There are other fisheries beside trawl and hook and line, for example, crab are trapped on Dogfish Bank to the east of the Charlottes. Production spikes have been noted and it is desirable to obtain more information about what drives their dynamics. There is also a shrimp fishery and a large herring fishery in spawning beds in coves along the coast of the Charlottes and the mainland.

Information has been submitted in a paper to the Fisheries Oceanography Journal and was presented at the last Fisheries Oceanography Committee (FOC) meeting in March (2002).

Plankton in Queen Charlotte Sd/Hecate Strait: What's Known (and What Isn't)

D. Mackas

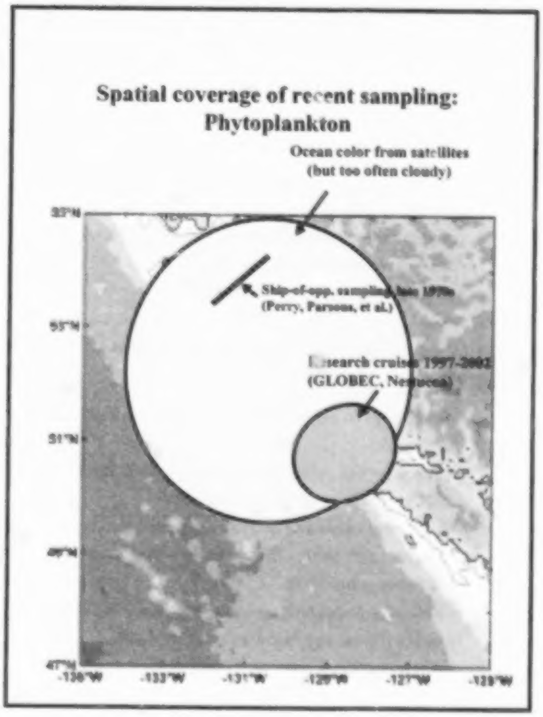
Fisheries and Oceans Canada



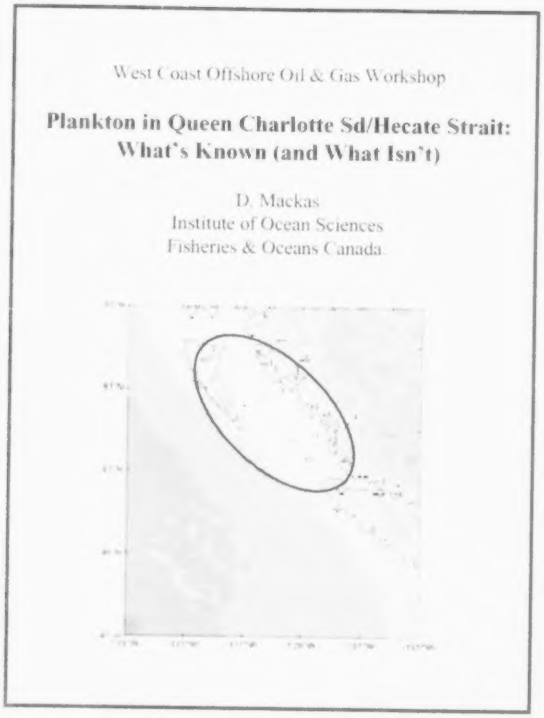
West Coast Offshore Oil & Gas Workshop

Plankton in Queen Charlotte Sd/Hecate Strait:
What's Known (and What Isn't)

D. Mackas
Institute of Ocean Sciences
Fisheries & Oceans Canada.



Spatial coverage of recent sampling:
Phytoplankton



West Coast Offshore Oil & Gas Workshop

Plankton in Queen Charlotte Sd/Hecate Strait: What's Known (and What Isn't)

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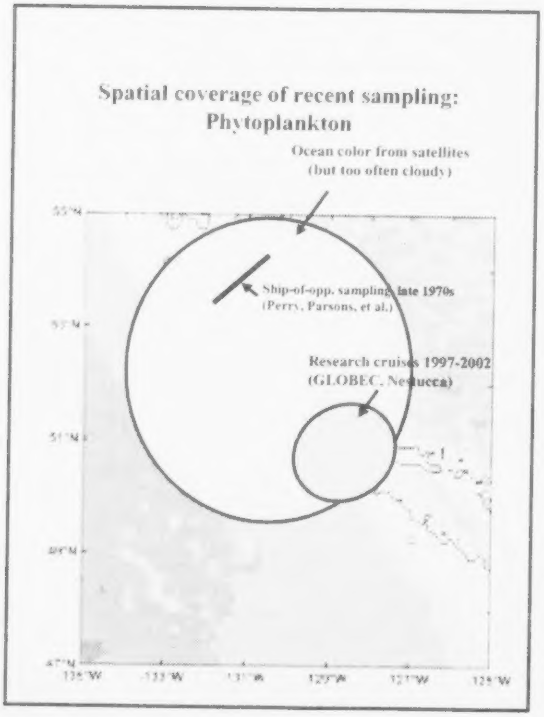


Spatial coverage of recent sampling: Phytoplankton

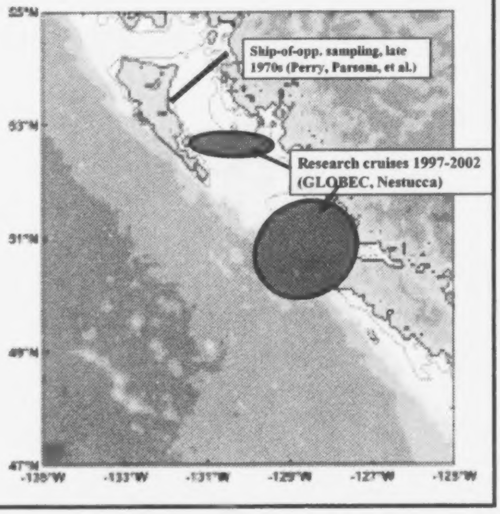
Ocean color from satellites (but too often cloudy)

Ship-of-opp. sampling, late 1970s (Perry, Parsons, et al.)

Research cruises 1997-2002 (GLOBEC, Nestucca)

Spatial coverage of recent sampling:

Zooplankton



Ship-of-opp. sampling, late 1970s (Perry, Parsons, et al.)

Research cruises 1997-2002 (GLOBEC, Nestucca)

What's known:

- Main nutrient supply mechanisms (tidal mixing, estuarine circulation, upwelling)
- Rough seasonal cycles of phytoplankton and zooplankton biomass & productivity
- Dominant zooplankton taxa
- Dominant prey-predator links??

What's probably true (based on studies elsewhere):

- Transfers to higher trophic levels are highly localised
- Trophic 'hot spots' often spatially associated with bathymetry & current patterns
- Large seasonal and interannual variability
- Direct acute toxic effects of oil on plankton are fairly small BUT
- Plankton 'hot spots' are aggregation foci for more vulnerable predators (seabirds, fish, mammals)

What's NOT known:

- Location and variability of trophic 'hot spots'
- Interannual variability of plankton productivity and community composition (except in southern QCS)
- Other details of spatial distributions (both vertical and horizontal), and implications for transfer of contaminants
- Open water occurrence of harmful algal blooms

West Coast Weather and Climate Issues

L. Neil

Environment Canada

West Coast Weather and Climate Issues

West Coast Oil & Gas Workshop

Institute of Ocean Sciences, 2003

Laurie Neil

EC/MSC/PYR

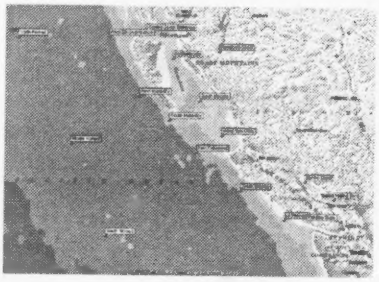
The Provincial Panel Report...

- did not adequately address weather and climate concerns
  - no meteorologists or climatologists on review panel or list of consultants
  - little acknowledgement of weather-related issues
  - panel members unaware of current climate change concerns

What we know...

- winds/wave data from 16 marine buoys since ~ 1990
- a few shore stations have provided hourly records for past 50-60 years
- lighthouse reports every 3 hours, daylight only

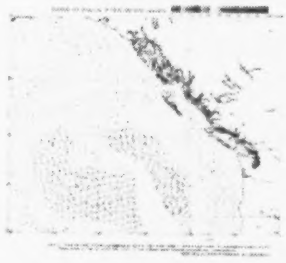
Marine Buoys...



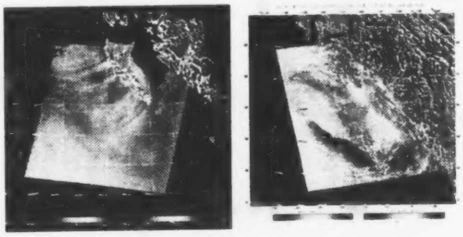
Other Observing Sites and Forecast Regions...

West Coast Marine Weather
Forecast Areas and Observation Sites
MAP KEY

Satellite-derived winds...



More Satellite Derived Winds..



Other assets…

- computing power
  - improved global and regional models
  - ensembles
  - 2.5 km mesoscale models
- radars
- ACARS/AMDAR
- lightning detection

Recent losses…

- high-quality manned observations
  - lighthouses, climate, others
- Automated Shipboard Aerological Program (ASAP)
- reduced MAREP program
- R&D capability has been impacted

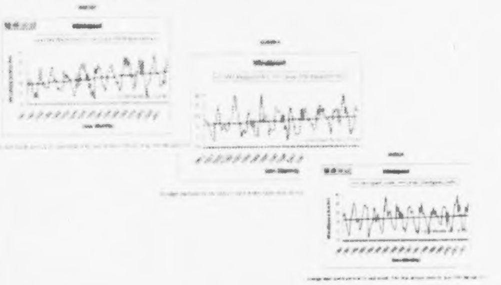
Knowledge gaps…

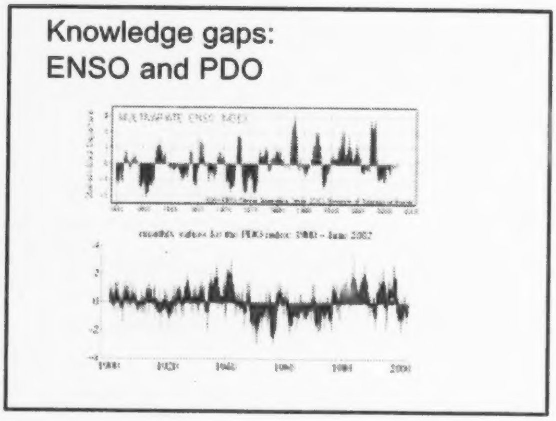
- incomplete knowledge of wind speeds and wave heights
  - current buoys measure only to 31 m
  - rogue waves
  - wind reports from coastal locations are sparse, sometimes unrepresentative

Knowledge gaps con't:
Climate change…

- Allan & Komer reported that 100 year significant wave off Washington coast increased from 10 to 16 m because of intense storms in the 1990's
  - what could be its cause?
  - what is the geographical distribution?

Knowledge gaps con't:
Wind speed trends…





Knowledge gaps: ENSO and PDO

Knowledge gaps, con't… Pacific Data Void

- lack of ***mid-tropospheric data***
- paper by Mass & McMurdie in upcoming issue of Weather & Forecasting shows that:
  - from Oct. 99 – Mar. 02, 48 hr fcst errors > 10 mb occur 10 – 15 times/year, avg. position error 475 km

    and errors > 15 mb occur 3 – 4 times/year
- 24 hr fcsts often bad as well

Knowledge gaps… Mesoscale wind variations

- lack of coastal radar data
- synthetic aperture radar data not fully utilized

Other Knowledge gaps…

- storm durations
  - for mitigation, rescue
- frequency of repeat storms (esp. marine bombs)
- mesoscale wind variations
- predictability
  - compared to other locations

Projects to address knowledge gaps…

- Frequencies and durations of extreme weather conditions
  - incl. magnitudes and return periods of high winds, snow and icing events, heavy rain, waterspouts and lightning
  - includes GIS-based reference system for identifying locations with high probabilities of hazardous conditions
  - utilize SAR winds
  - investigation of explosive cyclogenesis (marine bombs)
  - assessment of models

Projects to address knowledge gaps, con't…

- Predictability and the ***Pacific Data Void***
  - paucity of "upstream" mid-tropospheric data
  - analysis of forecasting skill along BC coast
  - study of innovative observation technologies
    - THORpex
      - aerosondes
      - dropsondes
      - rocketsondes
    - radar

Projects to address knowledge gaps, con't...

- Wind climatology for marine areas
    - develop high-resolution wind climatology of development areas
    - utilize SAR imagery
    - also emphasis on outflow plumes from coastal inlets

Projects to address knowledge gaps, con't...

- Periodic and Long Term Climate Change
    - suggestions of accelerated climate change
        - e.g. Allen & Komar (2002)
    - analysis of relationships between ENSO, PDO and climate change
    - investigation into changing synoptic patterns/storm tracks
    - experiments with numerical climate models (e.g. Canada's Global Climate Change model)

Projects to address knowledge gaps, con't...

- wave spectra and height maxima
    - study data from 16 marine buoys
- improved instrumentation on buoys
- special emphasis on rogue waves
- wave modeling with emphasis on rapid wave growth near frontal systems (IOS)

Projects to address knowledge gaps, con't...

- Establish Chair for Applied Meteorological Impacts at UBC
    - facilitate incorporation of academic research into marine R&D efforts
    - build on *CICMMH* initiatives, also links to UNBC
    - focus academic attention/research on offshore hydrocarbon issues

Conclusions

- Pacific is largest ocean in the world
- deep lows, explosive cyclogenesis are common
- multiple wave trains, swells from NW thru S plus wind waves
- storm force arctic outflow through inlets extends offshore
    - structural and vessel icing
- unique predictability issues due to data void
- weather issues should not be downplayed!

Winds whack Westshore

Discussion

Stating the largest wave and highest wind velocity in Hecate Strait is difficult. Maximum waves may be higher than we think. There is a problem of buoys truncating the maximum height, and shallow water effects increase the wave height. There are very strong tidal currents in and around the Charlottes, which steepen the waves if not increase their height. Maximum waves are probably 20-33 m. Every year there are hurricane-force winds in coastal waters.

So far, shallow water effects are not included in the operational wave forecasts. The Marine Forecast Centre in Vancouver currently provides forecasts. We are just now becoming aware of mesoscale variations in the wind field and their effects on waves. There are dramatic wave effects near shore with a lot of variation and these are not included in the operational forecast. Forecasters in Vancouver use the Global Environmental Model but are not constrained to this model; they will use whatever model they feel is best. One wave model, used by the Forecast Production Assistant group, makes use of CMC grid-point initialisation data over the entire Pacific. Currently, they use the wave model guidance that comes from CMC in addition to the atmospheric guidance. They are not using their own wave model as they were five or six years ago.

The new buoy sensor package using completely new technology is much better. They will be located on the Great Lakes, Lake Winnipeg, and one each on the East and West coasts.

Pacific storms are just as strong as those on the East coast. There have been a couple of huge storms in the Pacific. Small storms can be tighter but more devastating than the bigger ones. The dynamics of storm development on the two coasts are quite different. On the East Coast the Gulf Stream is a source of heat and moisture. On the West Coast there are other factors such as stronger jet streams and more fetch.

It is suggested that since each rig has 24-hour forecasting in terms of hazards, the data gap mostly relates to shipping routes and the fishing industry. On the East Coast there are 24-hour forecasts as well as private forecasting services. This would likely happen on the West Coast as well. Just because rigs are floating and are large does not mean they are not affected by bad weather and seas. Floating drilling platforms stay put and sustain whatever comes at them. We do not know some of the conditions we need to know for engineering design purposes. Our period of record is too short and we may have climate change altering the picture. A lot of projects are proposed to address these issues. The more activity you have offshore, whether it is oil drilling or fishing or something else, it is subject to weather and waves and that is where the issues lie.

Offshore Oil and Gas and the UNBC Northern Coastal Information and Research Program (NCIRP)

N. Dale
University of Northern British Columbia

Offshore Oil and Gas and the UNBC Northern Coastal Information and Research Program (NCIRP)

Presentation to West Coast Offshore Oil and Gas Workshop, January 8-10, 2003
By Norman Dale

Northern Land Use Institute
University of Northern British Columbia

UNBC/NCIRP is not alone!

- "Academia"
  - –Coasts Under Stress (UVIC & others)
  - –Royal Roads University
  - –SFU Centre for Coastal Studies
  - –UBC Fisheries Centre Hecate Strait work
  - –Northwest Community College
- New BC Offshore Oil and Gas Team
- PERD, COOGER, WED

Beginnings

New wave of interest in Northwestern BC in offshore development – mid to late 1990s

- **Offshore Oil & Gas Task Force**
- **Independent Scientific Review Panel**

Task Force says ...

- **make efforts to work cooperatively with First Nations to address economic & environmental concerns...encourage their involvement in the process of economic renewal.**
- **Exploration and development need to be based on sound science and careful risk-benefit analysis.**
- **Assurances needed that healthy fisheries /tourism industries can operate alongside offshore oil & gas development.**
- **Do assessment of benefits and costs to local communities.**

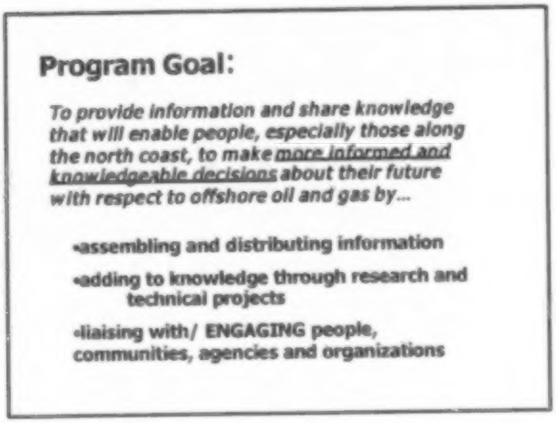
Scientific Panel says...

- **Gain significantly higher understanding of sea-bottom &sub-surface conditions of the BC offshore**
- **Establish comprehensive pre-perturbation baseline data on biota, including life-cycle histories and habitnts...(so as to) understand and assess which aspects of the marine ecosystem might be most at risk**
- **Complete critical data-bases**
- **Do thorough cost-benefit analysis ... to assess alternative strategies for uses of the marine ecosystem**
- **Set guidelines on impacts of seismic exploration on the ecosystem;**
- **Design a strategy for the training of British Columbians for the wide range of job requirements and opportunities**

Northern Coastal Information and Research Program (NCIRP)

Inaugurated with a grant from BC to the UNBC

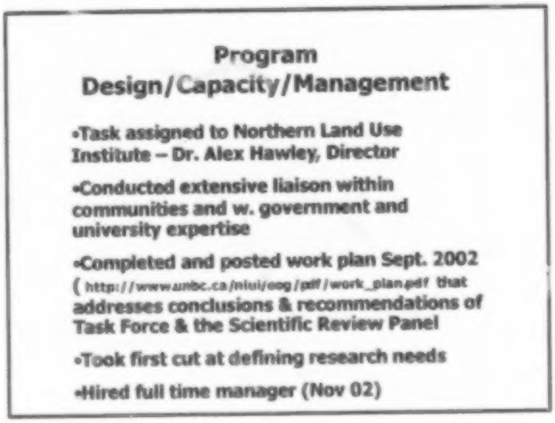
- **$2 million , starting May 2002**
- **"to advance the state of scientific and other knowledge related to offshore oil and gas"**



Program Goal:

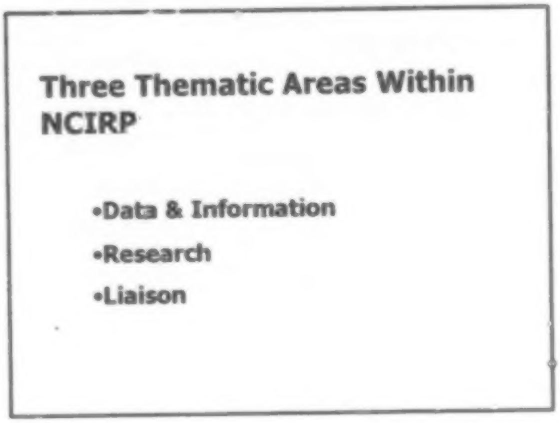
To provide information and share knowledge that will enable people, especially those along the north coast, to make more informed and knowledgeable decisions about their future with respect to offshore oil and gas by...

- •assembling and distributing information
- •adding to knowledge through research and technical projects
- •liaising with/ ENGAGING people, communities, agencies and organizations



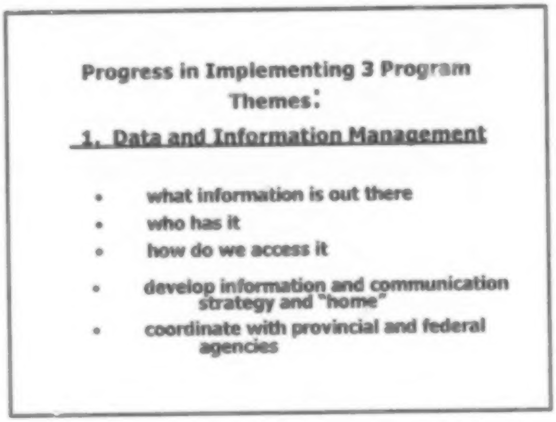
Program Design/Capacity/Management

- •Task assigned to Northern Land Use Institute – Dr. Alex Hawley, Director
- •Conducted extensive liaison within communities and w. government and university expertise
- •Completed and posted work plan Sept. 2002 (http://www.unbc.ca/nlui/oog/pdf/work_plan.pdf that addresses conclusions & recommendations of Task Force & the Scientific Review Panel
- •Took first cut at defining research needs
- •Hired full time manager (Nov 02)



Three Thematic Areas Within NCIRP

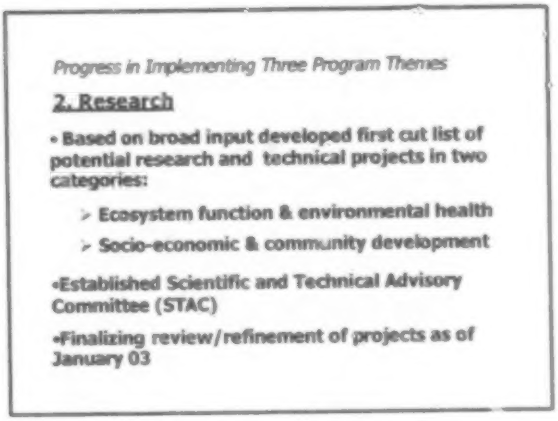
- •Data & Information
- •Research
- •Liaison



Progress in Implementing 3 Program Themes:

1. Data and Information Management

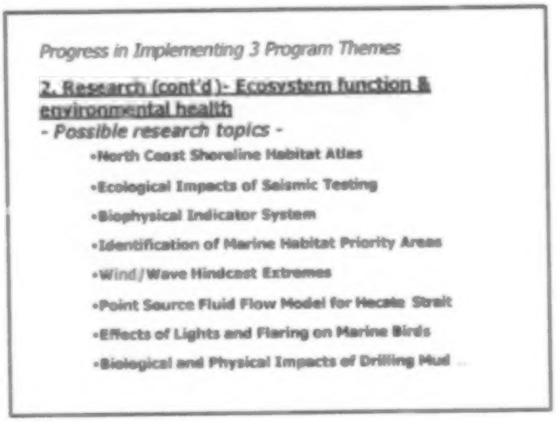
- what information is out there
- who has it
- how do we access it
- develop information and communication strategy and "home"
- coordinate with provincial and federal agencies



Progress in Implementing Three Program Themes

2. Research

- • Based on broad input developed first cut list of potential research and technical projects in two categories:
  - ➢ Ecosystem function & environmental health
  - ➢ Socio-economic & community development
- •Established Scientific and Technical Advisory Committee (STAC)
- •Finalizing review/refinement of projects as of January 03

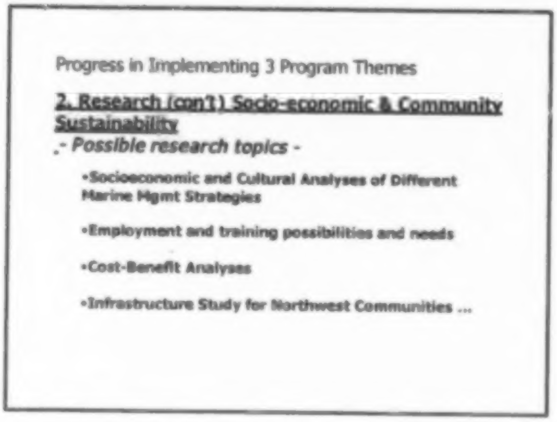


Progress in Implementing 3 Program Themes

2. Research (cont'd)- Ecosystem function & environmental health

- Possible research topics -

- •North Coast Shoreline Habitat Atlas
- •Ecological Impacts of Seismic Testing
- •Biophysical Indicator System
- •Identification of Marine Habitat Priority Areas
- •Wind/Wave Hindcast Extremes
- •Point Source Fluid Flow Model for Hecate Strait
- •Effects of Lights and Flaring on Marine Birds
- •Biological and Physical Impacts of Drilling Mud ...

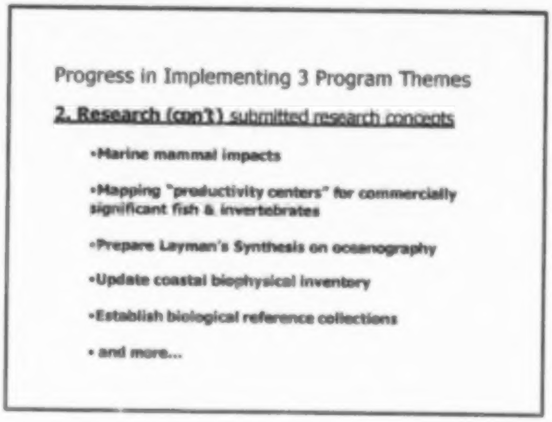


Progress in Implementing 3 Program Themes

2. Research (con't) Socio-economic & Community Sustainability

.- *Possible research topics* -

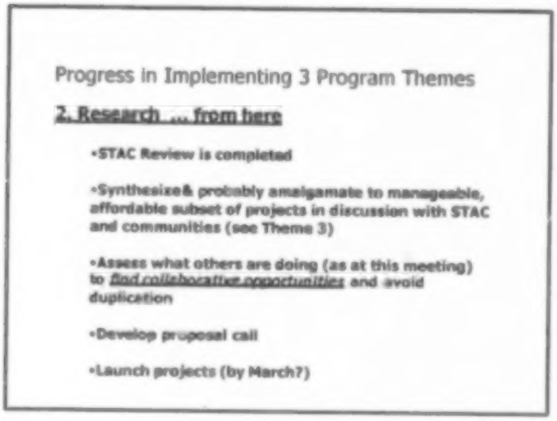
- **Socioeconomic and Cultural Analyses of Different Marine Mgmt Strategies**
- **Employment and training possibilities and needs**
- **Cost-Benefit Analyses**
- **Infrastructure Study for Northwest Communities ...**



Progress in Implementing 3 Program Themes

2. Research (con't) submitted research concepts

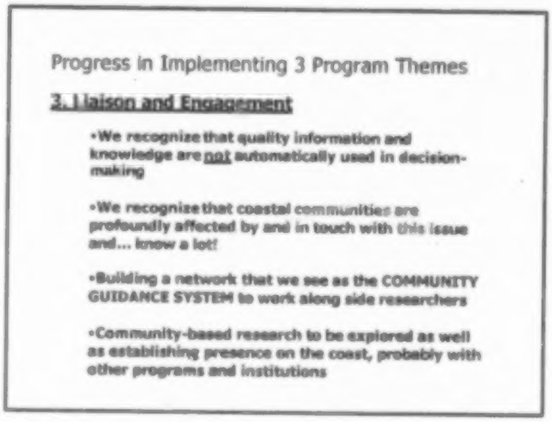
- **Marine mammal impacts**
- **Mapping "productivity centers" for commercially significant fish & invertebrates**
- **Prepare Layman's Synthesis on oceanography**
- **Update coastal biophysical inventory**
- **Establish biological reference collections**
- **and more...**



Progress in Implementing 3 Program Themes

2. Research ... from here

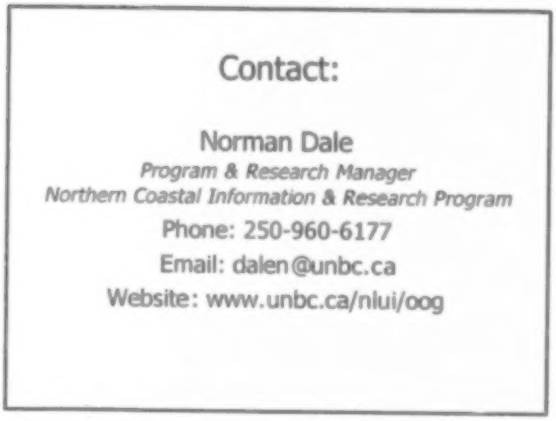
- **STAC Review is completed**
- **Synthesize& probably amalgamate to manageable, affordable subset of projects in discussion with STAC and communities (see Theme 3)**
- **Assess what others are doing (as at this meeting) to *find collaborative opportunities* and avoid duplication**
- **Develop proposal call**
- **Launch projects (by March?)**



Progress in Implementing 3 Program Themes

3. Liaison and Engagement

- **We recognize that quality information and knowledge are not automatically used in decision-making**
- **We recognize that coastal communities are profoundly affected by and in touch with this issue and... know a lot!**
- **Building a network that we see as the COMMUNITY GUIDANCE SYSTEM to work along side researchers**
- **Community-based research to be explored as well as establishing presence on the coast, probably with other programs and institutions**



Contact:

Norman Dale
Program & Research Manager
Northern Coastal Information & Research Program
Phone: 250-960-6177
Email: dalen@unbc.ca
Website: www.unbc.ca/nlui/oog

Discussion

Integrating traditional ecological knowledge would have to happen in a number of ways. It has been suggested that the subject could be taken aside as a consultative research topic but experience working with First Nations goes against that because it tends to ghettoize the results. We are looking at over-layering the Terms of Reference on anything in the proposal to the fullest extent possible in a creative and sincere approach to incorporating traditional ecological knowledge. We need to recognise too that a lot of the traditional knowledge comes from fishermen and others who have lived on the coast for generations.

At the moment, there is no formal link to DFO's Marine Environmental Data Service (MEDS) database. It will be necessary to liaise with others who have database expertise. Those who have or use relevant databases as part of their research should get in touch with Norm Dale (UNBC – NCIRP).

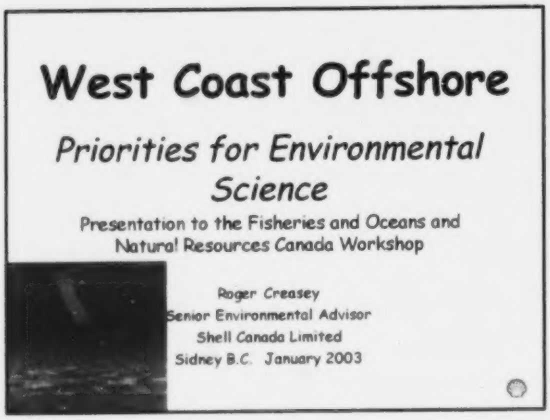
There is no industry representative on the Advisory Committee of our program. The first task of the committee, review at a broad level, is drawing to a close. The committee is not closed at this point and the role of industries will be discussed.

$2 million exists in the program. Advice is to not get too many projects, a few amalgamated projects are preferred. Who does the work is not yet known, but it will certainly involve partnering with research groups that are non-consultant (e.g., government institutes and First Nations). Nothing is ruled out.

The Community Guidance System will develop community involvement in fine tuning research questions, in evolving project objectives, in reviewing work as it happens and finding other opportunities for community involvement. Researchers need advice and guidance based on local knowledge.

Priorities for Environmental Science

R. Creasey
Shell Canada Limited

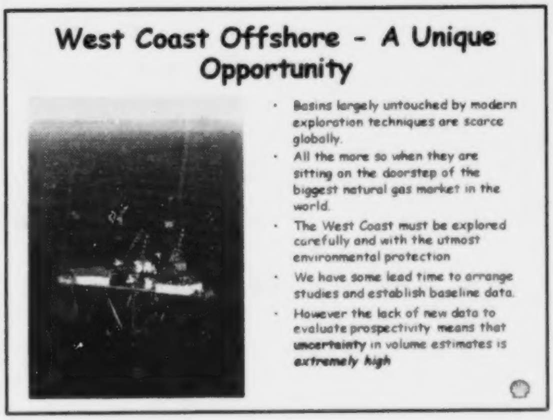


West Coast Offshore

Priorities for Environmental Science

Presentation to the Fisheries and Oceans and Natural Resources Canada Workshop

Roger Creasey
Senior Environmental Advisor
Shell Canada Limited
Sidney B.C. January 2003



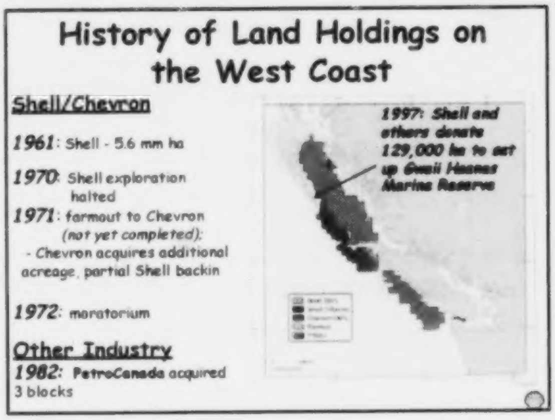
West Coast Offshore - A Unique Opportunity

- Basins largely untouched by modern exploration techniques are scarce globally.
- All the more so when they are sitting on the doorstep of the biggest natural gas market in the world.
- The West Coast must be explored carefully and with the utmost environmental protection
- We have some lead time to arrange studies and establish baseline data.
- However the lack of new data to evaluate prospectivity means that **uncertainty** in volume estimates is ***extremely high***

Key Issues

Who has the lead?

- *Industry* Hydrocarbon Prospectivity
- *Gov't/others* Clear Ownership, Access to Resources
- Regulatory and Fiscal terms (economics)
- *Joint* Environmental Sensitivities
- Access to Markets
- Sustainable Development



History of Land Holdings on the West Coast

Shell/Chevron

1961: Shell - 5.6 mm ha

1970: Shell exploration halted

1971: farmout to Chevron *(not yet completed)*;
- Chevron acquires additional acreage, partial Shell backin

1972: moratorium

Other Industry

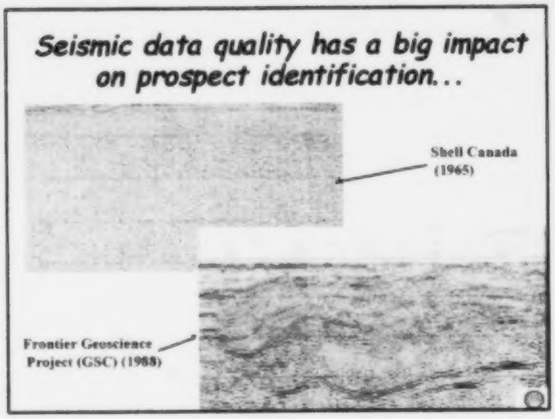
1982: **PetroCanada** acquired 3 blocks

1997: Shell and others donate 129,000 ha to set up Gwaii Haanas Marine Reserve

Hydrocarbon Prospectivity

We Need: Early Seismic Coverage

- Huge uncertainty in resource potential offshore West Coast requires that we acquire a new subsurface data set
- ***pre-commitment regional*** seismic ***vs*** ***post-commitment detailed*** seismic
  - regional seismic surveys - "speculative" basis prior to land commitment? (open participation by industry)
  - detailed prospect surveys - done to fulfil E.L. work program commitments on a proprietary basis
- Drilling in a new area requires detailed seismic (thus, after the second seismic season)



Seismic data quality has a big impact on prospect identification...

Shell Canada (1965)
Frontier Geoscience Project (GSC) (1988)

...Environmental Sensitivities

We Need: Early Designation of Protected Areas

- Early initiation of environmental and baseline studies, and collation of existing information..
- Early stakeholder engagement and identification of protected areas.
- Examination and refinement of seismic and drilling buffer zones reflecting possible prospectivity and modern technology.

...Regulatory and Fiscal terms (1)

We Need: An Effective Regulatory Framework...

- Establishment of an effective regulatory framework
- Simple but effective rulebook ("Regulatory Roadmap")
- a "one-stop" window for regulatory approvals (minimize jurisdictional overlap and conflict)
- Smooth transition from Permits to E.L.'s. for existing landholders
- Clear environmental assessment process, focus Term of Reference (TOR)
- Key lessons available from East Coast experience (CAPP)
- Consider strategic EA of regional activity augmented with project EAs
- appointment of a dedicated provincial offshore oil and gas team to "work the issues" is a crucial first step in this... (but will require cooperation from the Government of Canada)

... Sustainable Development (1)

Implement Sustainable Development

- Using Shell Canada's policy as an example:
  - no harm to PEOPLE - skills of West Coast work force (risk phase vs project development phase)
  - protect the ENVIRONMENT and pursue the goal of prevention of pollution
  - use material and ENERGY efficiently to provide our products and services
  - DEVELOP energy resources in line with the above aims

... Sustainable Development (2)

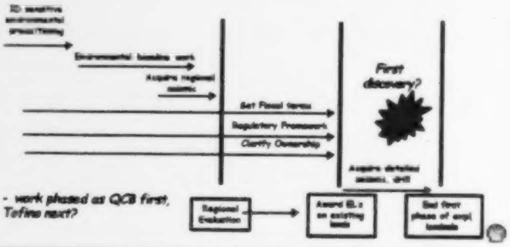
...Sustainable Development continued

- engage in stakeholder CONSULTATION
- play a leading role in PROMOTING best practice in our industry
- manage health, safety and SUSTAINABLE development as any other critical business activity
- implement action to conserve biodiversity
- promote a CULTURE in which all Shell employees share this commitment

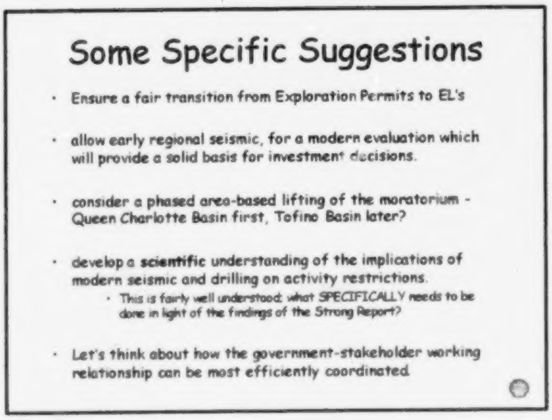
Concurrent or Consecutive?

- many major pieces to the puzzle - regulatory, fiscal, environmental, technical, political and aboriginal.
  - If we wait for each to be concluded before the other starts we will be extend the timeline significantly (and it's already long!)
- At this early stage, let's do things in parallel where possible - land use and environmentally-based zoning, early seismic, land claims negotiations and regulatory/fiscal framework.
- This way, when a clear green light is given, the industry will be ready to move forward, in concert with the regulatory regime and the public.

Proposed Initial Steps to Facilitate West Coast Activity (concurrent "fastrack" model)

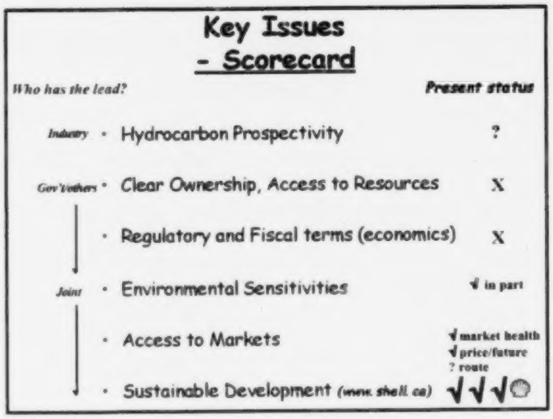

ID sensitive environmental areas/Timing
Environmental baseline work
Acquire regional seismic
Set Fiscal terms
Regulatory Framework
Clarify Ownership
First discovery?
Acquire detailed seismic, drill
Regional Evaluation
Award EL's on existing lands
Bid first phase of expl. lands

- work phased as QCB first, Tofino next?



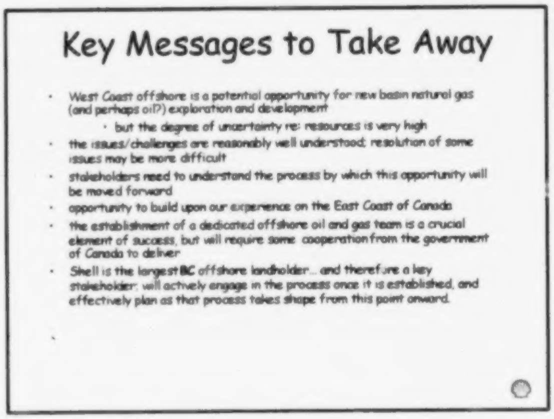
Some Specific Suggestions

- Ensure a fair transition from Exploration Permits to EL's
- allow early regional seismic, for a modern evaluation which will provide a solid basis for investment decisions.
- consider a phased area-based lifting of the moratorium - Queen Charlotte Basin first, Tofino Basin later?
- develop a **scientific** understanding of the implications of modern seismic and drilling on activity restrictions.
  - This is fairly well understood; what SPECIFICALLY needs to be done in light of the findings of the Strong Report?
- Let's think about how the government-stakeholder working relationship can be most efficiently coordinated.



Key Issues
- Scorecard

Who has the lead?		*Present status*
Industry	Hydrocarbon Prospectivity	?
Gov't/others	Clear Ownership, Access to Resources	X
	Regulatory and Fiscal terms (economics)	X
Joint	Environmental Sensitivities	√ in part
	Access to Markets	√ market health √ price/future ? route
	Sustainable Development *(www.shell.ca)*	√ √ √



Key Messages to Take Away

- West Coast offshore is a potential opportunity for new basin natural gas (and perhaps oil?) exploration and development
  - but the degree of uncertainty re: resources is very high
- the issues/challenges are reasonably well understood; resolution of some issues may be more difficult
- stakeholders need to understand the process by which this opportunity will be moved forward
- opportunity to build upon our experience on the East Coast of Canada
- the establishment of a dedicated offshore oil and gas team is a crucial element of success, but will require some cooperation from the government of Canada to deliver
- Shell is the largest BC offshore landholder... and therefure a key stakeholder; will actively engage in the process once it is established, and effectively plan as that process takes shape from this point onward.

Discussion

For the oil and gas industry, "protected areas" generally refer to areas where no drilling will occur, but can also apply to areas where some seasonal or intensity restrictions apply. Industry is still learning how to deal with Marine Protected Areas (MPAs). The issue is what the impact would be, even if activity is short-term and localized. If there is an impact, it must be temporary if at all possible. Aesthetics of drill rigs in sensitive areas, for example near parks, is an issue.

The West Coast area is thought to have indications of natural gas. The environmental hazards from gas exploration and oil exploration differ. Gas pressures are sometimes higher and this has to be taken into account when designing the drilling system. Sour gas production wells demand more design and management considerations.

Gas fits into Shell's 50-year plan for getting prepared for the decarbonisation of fuels worldwide. Shell is in the wind power business and is moving toward becoming a hydrogen economy company.

Vessel traffic on the West Coast differs from the East Coast. For example, consider Hecate Strait versus Sable Island Bank or George's Bank. Hecate Strait is more constricted, may have different traffic patterns and has certain kinds of traffic such as barges and cruise ships. Factors reducing risk are the Notice to Mariners, better training and an exclusion zone around rigs.

Shell's participation in resolving environmental issues or assisting in the collection of baseline information, in some way prior to the lifting of the moratorium, is not out of the question. Shell has not been asked at this point and it must be recognised that it is harder to get approval before the moratorium is lifted on a purely business basis. A reasonable, pre-emptive project of some kind could be considered, something along the lines of collating known information or archiving. There are other companies that might wish to have a presence on the West Coast. It would be good to liase and to see industry people participate in a mini-version of this workshop.

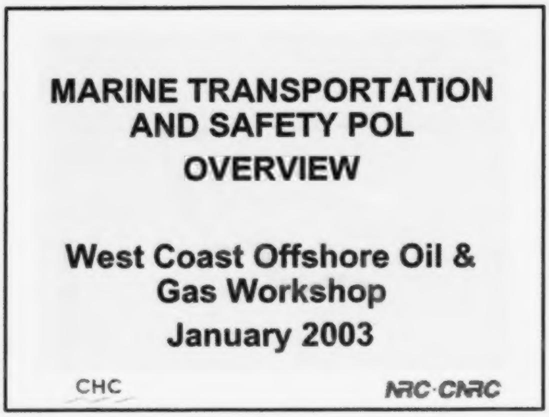
If there were appreciable signs of hydrocarbons in the North that would stimulate interest, seismics could occur in both the Queen Charlotte and Tofino areas at the same time, although staging is a possibility, but there are other considerations such as parks being nearby. The whole issue of where and when exploration will be initiated is unanswered at the moment.

"Rights" mean the company has a legal right to access oil and gas resources in a specific area. The moratorium has delayed the issuing of licences. Usually companies have a five-year period with the possibility of renewal for another year. They have to drill or improve their holdings or these could revert to the government and be sold again. The moratorium has suspended this process. Until the moratorium is lifted, there will not be an opportunity for the company to act. In Alberta, the energy industry drills about 14,000 wells a year. Many times these rights are bought and sold or the company doesn't explore, and they revert back to the crown because government wants to see the resource developed. There is also the question of what regulatory framework and level of environmental impact assessment will be required. In terms of the regulatory road map that provides for the exploratory stage but not the development stage, industry would not see this as an impediment because industry really starts with the exploratory phase.

Marine Transportation and Safety POL 1.2.3 Overview

B. Frederking

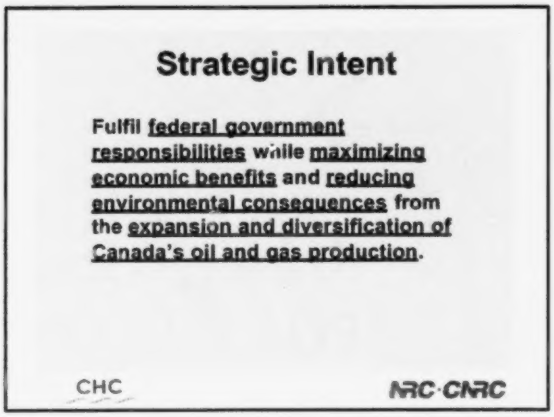
Natural Resources Canada



MARINE TRANSPORTATION AND SAFETY POL OVERVIEW

West Coast Offshore Oil & Gas Workshop
January 2003

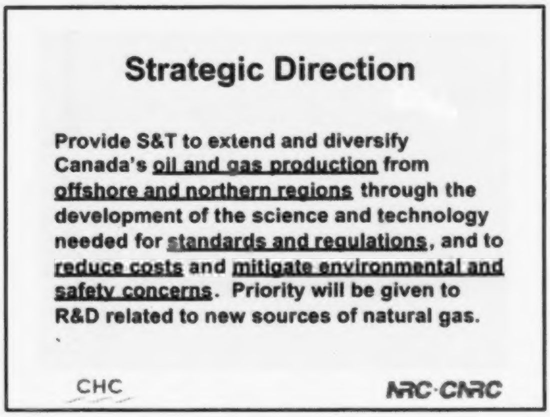
CHC
NRC·CNRC



Strategic Intent

Fulfil federal government responsibilities while maximizing economic benefits and reducing environmental consequences from the expansion and diversification of Canada's oil and gas production.

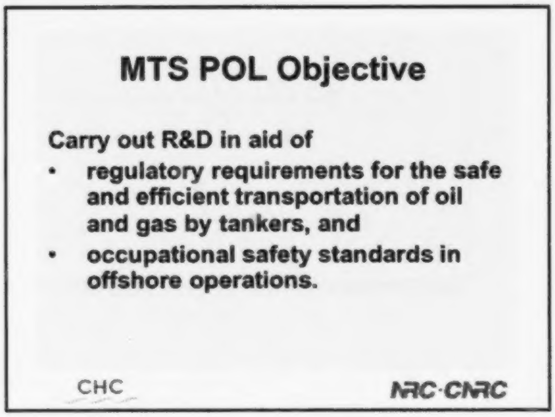
CHC
NRC·CNRC



Strategic Direction

Provide S&T to extend and diversify Canada's oil and gas production from offshore and northern regions through the development of the science and technology needed for standards and regulations, and to reduce costs and mitigate environmental and safety concerns. Priority will be given to R&D related to new sources of natural gas.

CHC
NRC·CNRC

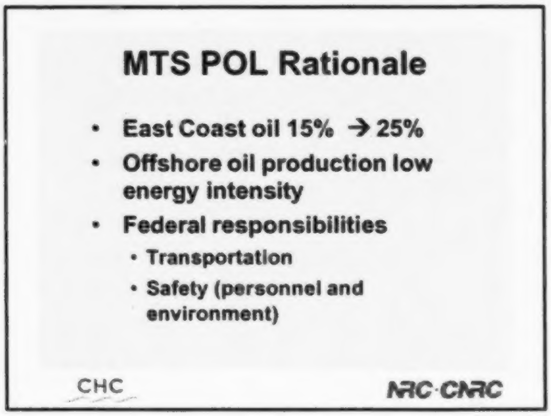


MTS POL Objective

Carry out R&D in aid of

- regulatory requirements for the safe and efficient transportation of oil and gas by tankers, and
- occupational safety standards in offshore operations.

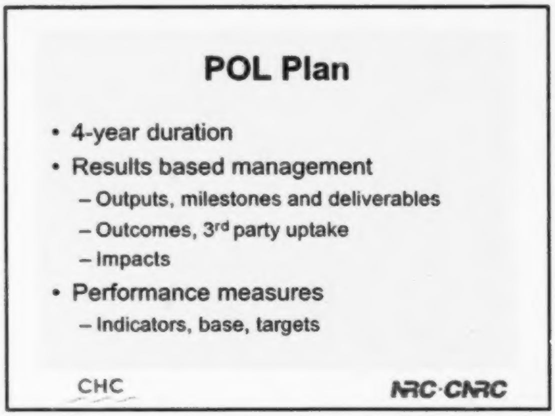
CHC
NRC·CNRC



MTS POL Rationale

- East Coast oil 15% → 25%
- Offshore oil production low energy intensity
- Federal responsibilities
  - Transportation
  - Safety (personnel and environment)

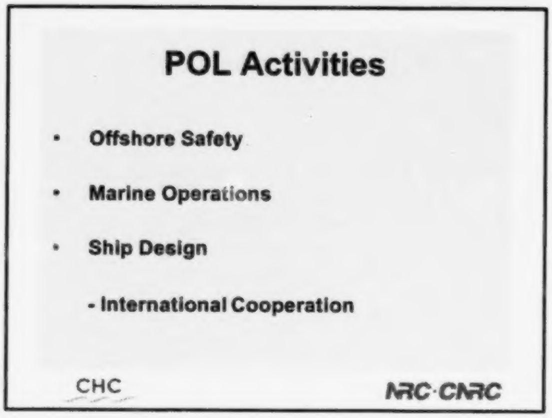
CHC
NRC·CNRC



POL Plan

- 4-year duration
- Results based management
  - Outputs, milestones and deliverables
  - Outcomes, 3rd party uptake
  - Impacts
- Performance measures
  - Indicators, base, targets

CHC
NRC·CNRC



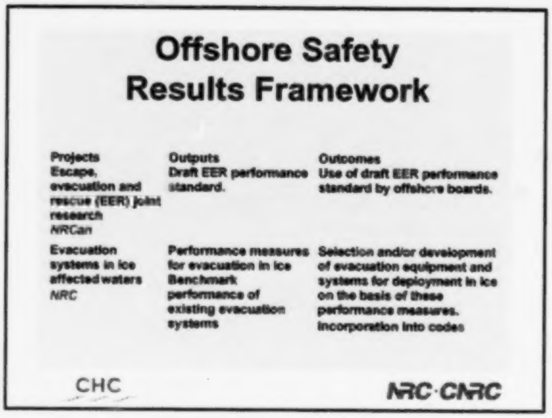
POL Activities

- Offshore Safety
- Marine Operations
- Ship Design

  - International Cooperation

CHC

NRC·CNRC

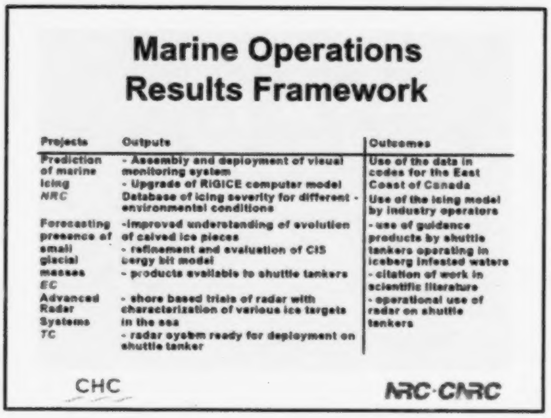


Offshore Safety Results Framework

Projects	Outputs	Outcomes
Escape, evacuation and rescue (EER) joint research *NRCan*	Draft EER performance standard.	Use of draft EER performance standard by offshore boards.
Evacuation systems in ice affected waters *NRC*	Performance measures for evacuation in ice Benchmark performance of existing evacuation systems	Selection and/or development of evacuation equipment and systems for deployment in ice on the basis of these performance measures. Incorporation into codes

CHC

NRC·CNRC



Marine Operations Results Framework

Projects	Outputs	Outcomes
Prediction of marine icing *NRC*	- Assembly and deployment of visual monitoring system - Upgrade of RIGICE computer model Database of icing severity for different - environmental conditions	Use of the data in codes for the East Coast of Canada Use of the icing model by industry operators
Forecasting presence of small glacial masses *EC*	-improved understanding of evolution of calved ice pieces - refinement and evaluation of CIS bergy bit model - products available to shuttle tankers	- use of guidance products by shuttle tankers operating in iceberg infested waters - citation of work in scientific literature
Advanced Radar Systems *TC*	- shore based trials of radar with characterization of various ice targets in the sea - radar system ready for deployment on shuttle tanker	- operational use of radar on shuttle tankers

CHC

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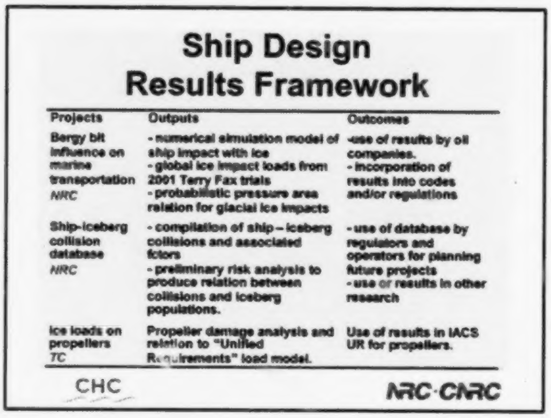
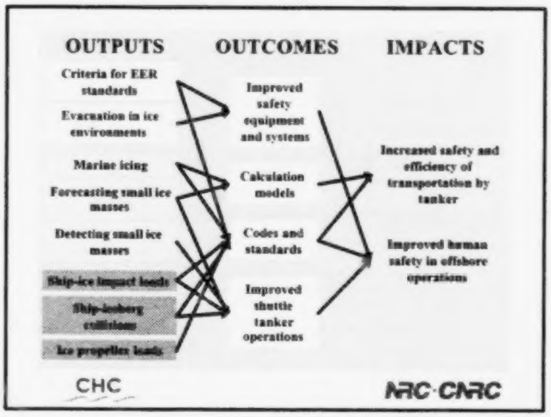


Ship Design Results Framework

Projects	Outputs	Outcomes
Bergy bit influence on marine transportation *NRC*	- numerical simulation model of ship impact with ice - global ice impact loads from 2001 Terry Fax trials - probabilistic pressure area relation for glacial ice impacts	-use of results by oil companies. - incorporation of results into codes and/or regulations
Ship-iceberg collision database *NRC*	- compilation of ship – iceberg collisions and associated fctors - preliminary risk analysis to produce relation between collisions and iceberg populations.	- use of database by regulators and operators for planning future projects - use or results in other research
Ice loads on propellers *TC*	Propeller damage analysis and relation to "Unified Requirements" load model.	Use of results in IACS UR for propellers.

CHC

NRC·CNRC



OUTPUTS

OUTCOMES

IMPACTS

Criteria for EER standards

Evacuation in ice environments

Marine icing

Forecasting small ice masses

Detecting small ice masses

Ship-ice impact loads

Ship-iceberg collisions

Ice propeller loads

Improved safety equipment and systems

Calculation models

Codes and standards

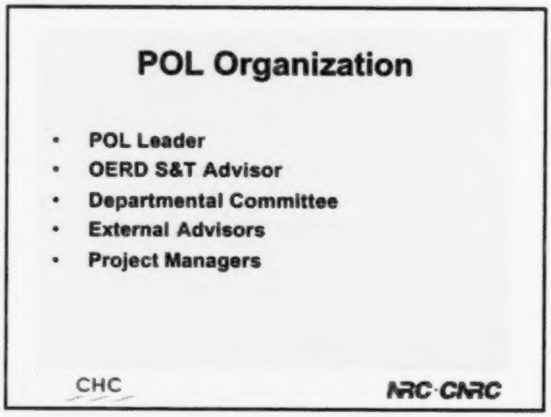
Improved shuttle tanker operations

Increased safety and efficiency of transportation by tanker

Improved human safety in offshore operations

CHC

NRC·CNRC



POL Organization

- POL Leader
- OERD S&T Advisor
- Departmental Committee
- External Advisors
- Project Managers

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POL Organization (a)

- POL Leader (R. Frederking, NRC)
- OERD S&T Advisor (S-L. Marshall)
- Departmental Committee
  - T. Carrieres (EC)
  - R. Gagnon (NRC
  - M. Hnetka (NRCan)
  - S. Prinsenberg (DFO)
  - P. Timonin (TC)

POL Organization (b)

External Advisors

- W. Bobby (CNOPB)
- A. Ewida (Petro-Canada)
- V. Santos-Pedro (TC)
- H. Vigen (Canship Ugland)

POL Organization (c)

Project Managers

- T. Carrieres (EC)
- R. Gagnon (NRC)
- C. Gautier (TC)
- B. Hill (NRC)
- M. Hnetka (NRCan)
- E. Radloff (TC)
- A. Simos Re (NRC)

Budget by Activity

Activity	02-03	03-04	*05-05*	*05-06*
1. Offshore Safety	180k	200k	*250k*	*250k*
2. Marine Operations	280k	250k	*210k*	*210k*
3. Ship Design	240k	250k	*240k*	*240k*

MTS Future Issues

- Other issues
  - Tanker loading and unloading
  - Personnel safety on FPSOs
  - Interest in frontier (Arctic)
  - West Coast

NRC in Offshore POLs

Environmental Forecasting and Design

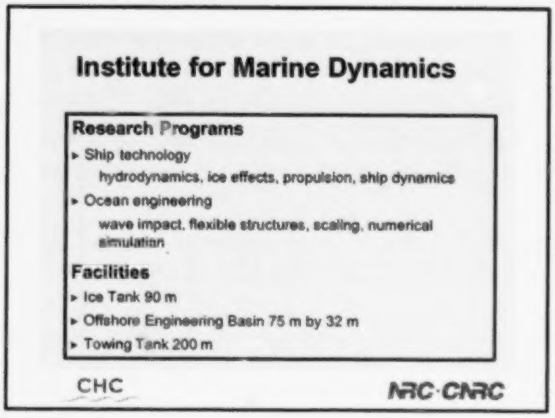
- ▸Ice-structure interaction (ISIAC)
  - ▸Ice forecast model for CIS/EC

Northern

- ▸Beaufort Sea experience for ice loads

Marine Transportation and Safety

- ▸Bergy bit impact
- ▸Marine Icing
- ▸Evacuation in Ice
- ▸EER



Institute for Marine Dynamics

Research Programs

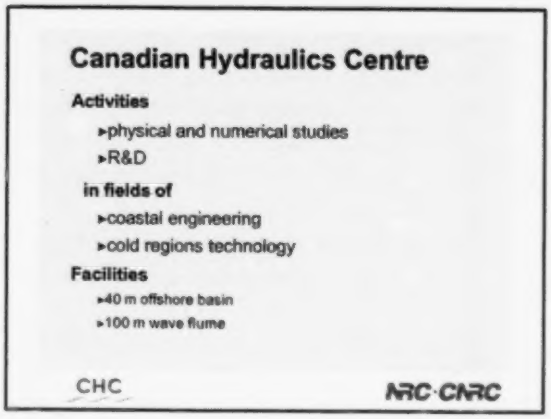
- Ship technology
  - hydrodynamics, ice effects, propulsion, ship dynamics
- Ocean engineering
  - wave impact, flexible structures, scaling, numerical simulation

Facilities

- Ice Tank 90 m
- Offshore Engineering Basin 75 m by 32 m
- Towing Tank 200 m

CHC

NRC·CNRC



Canadian Hydraulics Centre

Activities

- physical and numerical studies
- R&D

in fields of

- coastal engineering
- cold regions technology

Facilities

- 40 m offshore basin
- 100 m wave flume

CHC

NRC·CNRC

Discussion

Events such as a crane toppling by wind at a coal port would not be in the domain of the Program at Objective Level (POL) because it is land-based infrastructure. Wind damage to shipping facilities is a design problem requiring appropriate 100-year wind loads. Within the ESRF there is a Canadian Standards Association (CSA – a standards development body) offshore structures code so ESRF has taxed itself to provide some funding for the CSA to revise the existing code.

Marine transportation is an international issue. Probably 0.1% of ships in the world are Canadian or Canadian registered so focus is on areas such as cold or ice issues that others will not do.

There could be unique meteorological or oceanic conditions on the West Coast since it is hard to imagine that you would not find some unique aspects. Codes are reliability-based, so this puts a lot of responsibility on operators to prove their designs will meet a reliability level. Codes say you should not be in any more peril on a marine structure than on a land-based structure.

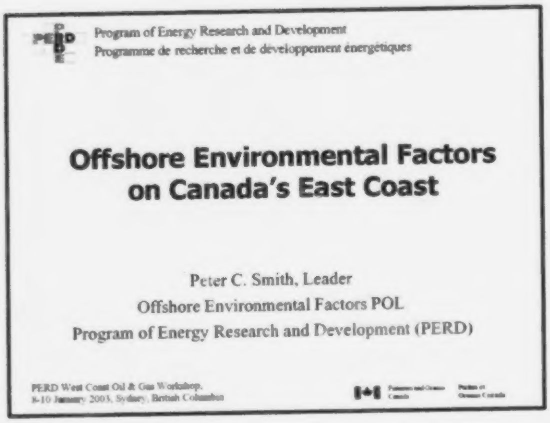
Wind R&D falls under the area of wind and waves in the Offshore Environmental Factors POL as it continues to be identified as an issue by the oil and gas industry. It may not be funded to the level requested, but all POLs have good projects that have to be put off due to budget constraints.

On the West Coast, marine accidents have tended to be collisions between vessels. Although the West Coast has many congested areas and strong currents this has not received particular attention. The POL has a new proposal looking at marine collisions but this focuses on collisions during loading. Tankers are a small part of the overall marine traffic although they are relatively unwieldy.

Offshore Environmental Factors on Canada's East Coast

POL 1.2.1 Overview

P. Smith
Fisheries and Oceans Canada



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Offshore Environmental Factors on Canada's East Coast

Peter C. Smith, Leader
Offshore Environmental Factors POL
Program of Energy Research and Development (PERD)

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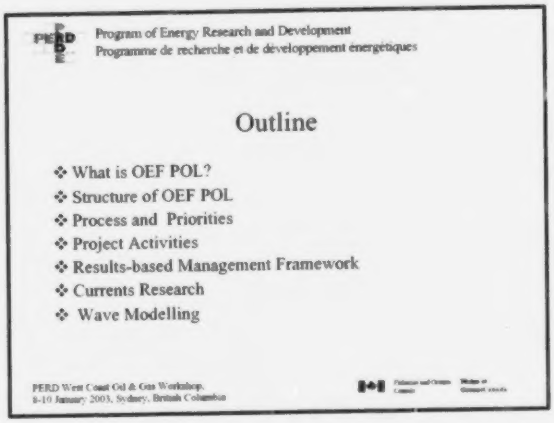

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Outline

- ❖ What is OEF POL?
- ❖ Structure of OEF POL
- ❖ Process and Priorities
- ❖ Project Activities
- ❖ Results-based Management Framework
- ❖ Currents Research
- ❖ Wave Modelling

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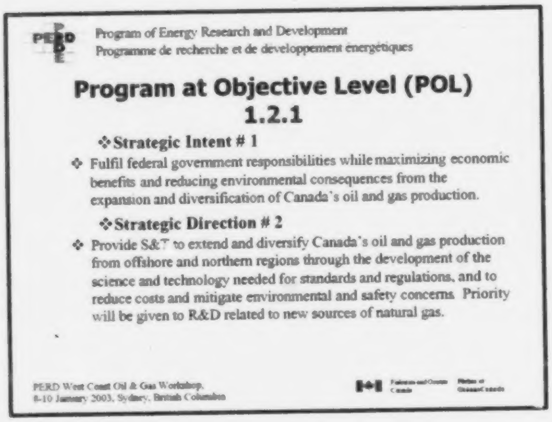

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Program at Objective Level (POL) 1.2.1

❖Strategic Intent # 1

❖ Fulfil federal government responsibilities while maximizing economic benefits and reducing environmental consequences from the expansion and diversification of Canada's oil and gas production.

❖Strategic Direction # 2

❖ Provide S&T to extend and diversify Canada's oil and gas production from offshore and northern regions through the development of the science and technology needed for standards and regulations, and to reduce costs and mitigate environmental and safety concerns. Priority will be given to R&D related to new sources of natural gas.

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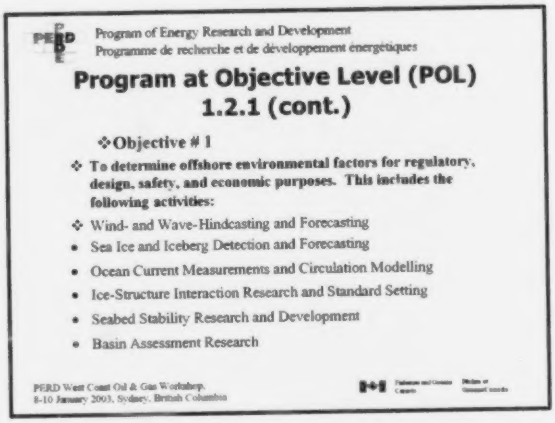

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Program at Objective Level (POL) 1.2.1 (cont.)

❖Objective # 1

❖ **To determine offshore environmental factors for regulatory, design, safety, and economic purposes. This includes the following activities:**

- ❖ Wind- and Wave-Hindcasting and Forecasting
- Sea Ice and Iceberg Detection and Forecasting
- Ocean Current Measurements and Circulation Modelling
- Ice-Structure Interaction Research and Standard Setting
- Seabed Stability Research and Development
- Basin Assessment Research

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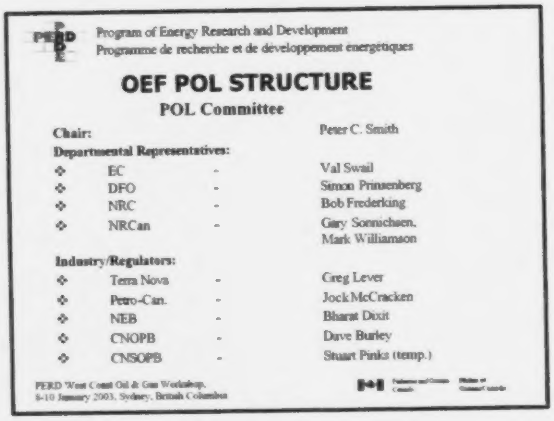

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OEF POL STRUCTURE

POL Committee

Chair: Peter C. Smith

Departmental Representatives:

- ❖ EC - Val Swail
- ❖ DFO - Simon Prinsenberg
- ❖ NRC - Bob Frederking
- ❖ NRCan - Gary Sonnichsen, Mark Williamson

Industry/Regulators:

- ❖ Terra Nova - Greg Lever
- ❖ Petro-Can. - Jock McCracken
- ❖ NEB - Bharat Dixit
- ❖ CNOPB - Dave Burley
- ❖ CNSOPB - Stuart Pinks (temp.)

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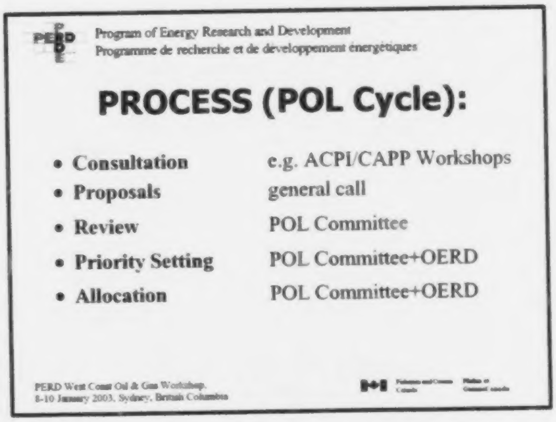

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PROCESS (POL Cycle):

• **Consultation**	e.g. ACPI/CAPP Workshops
• **Proposals**	general call
• **Review**	POL Committee
• **Priority Setting**	POL Committee+OERD
• **Allocation**	POL Committee+OERD

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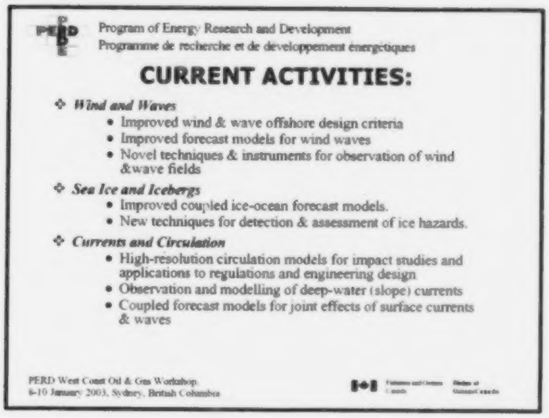

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CURRENT ACTIVITIES:

- ***Wind and Waves***
  - Improved wind & wave offshore design criteria
  - Improved forecast models for wind waves
  - Novel techniques & instruments for observation of wind &wave fields
- ***Sea Ice and Icebergs***
  - Improved coupled ice-ocean forecast models.
  - New techniques for detection & assessment of ice hazards.
- ***Currents and Circulation***
  - High-resolution circulation models for impact studies and applications to regulations and engineering design
  - Observation and modelling of deep-water (slope) currents
  - Coupled forecast models for joint effects of surface currents & waves

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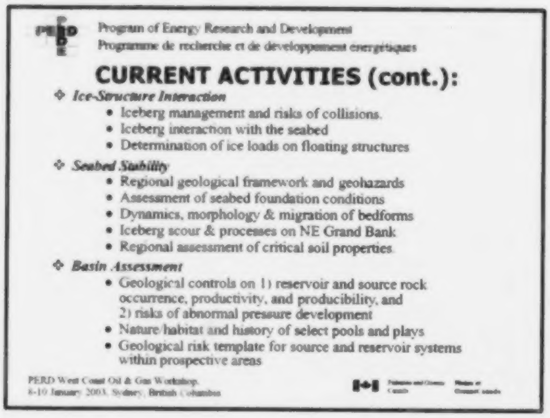

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CURRENT ACTIVITIES (cont.):

- ***Ice-Structure Interaction***
  - Iceberg management and risks of collisions.
  - Iceberg interaction with the seabed
  - Determination of ice loads on floating structures
- ***Seabed Stability***
  - Regional geological framework and geohazards
  - Assessment of seabed foundation conditions
  - Dynamics, morphology & migration of bedforms
  - Iceberg scour & processes on NE Grand Bank
  - Regional assessment of critical soil properties
- ***Basin Assessment***
  - Geological controls on 1) reservoir and source rock occurrence, productivity, and producibility, and 2) risks of abnormal pressure development
  - Nature/habitat and history of select pools and plays
  - Geological risk template for source and reservoir systems within prospective areas

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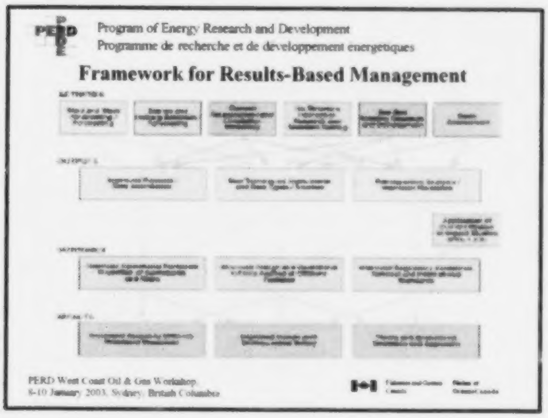

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Framework for Results-Based Management

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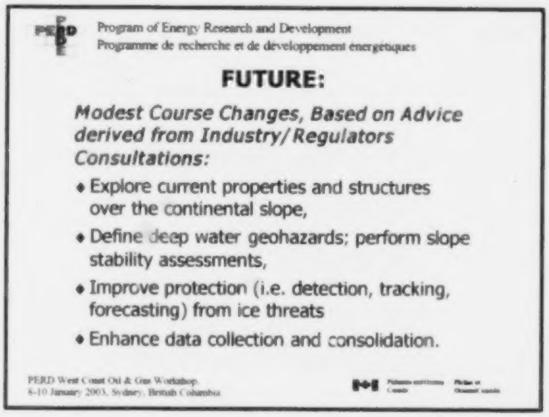

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FUTURE:

Modest Course Changes, Based on Advice derived from Industry/Regulators Consultations:

- Explore current properties and structures over the continental slope,
- Define deep water geohazards; perform slope stability assessments,
- Improve protection (i.e. detection, tracking, forecasting) from ice threats
- Enhance data collection and consolidation.

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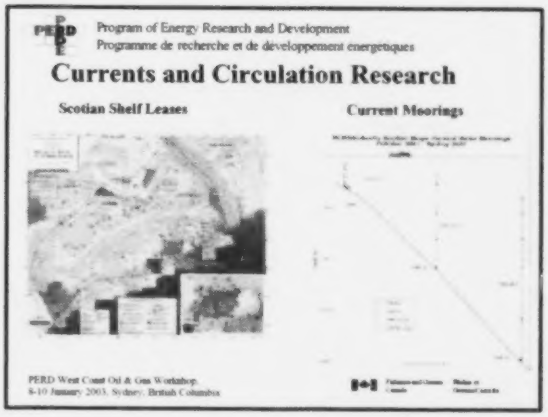

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Currents and Circulation Research

Scotian Shelf Leases **Current Moorings**

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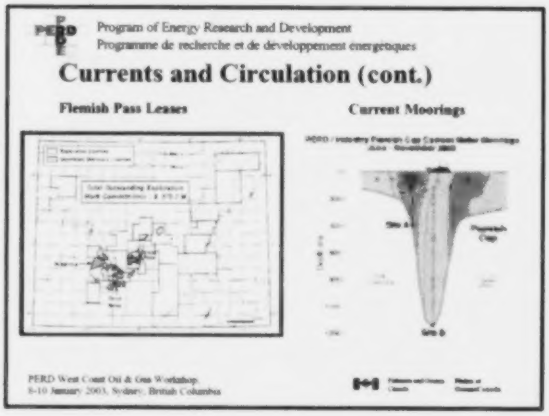

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Currents and Circulation (cont.)

Flemish Pass Leases **Current Moorings**

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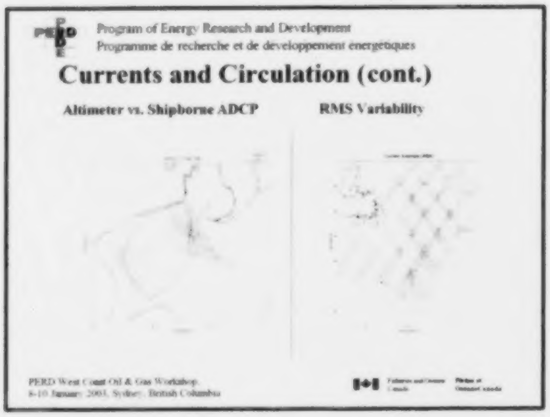

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Currents and Circulation (cont.)

Altimeter vs. Shipborne ADCP **RMS Variability**

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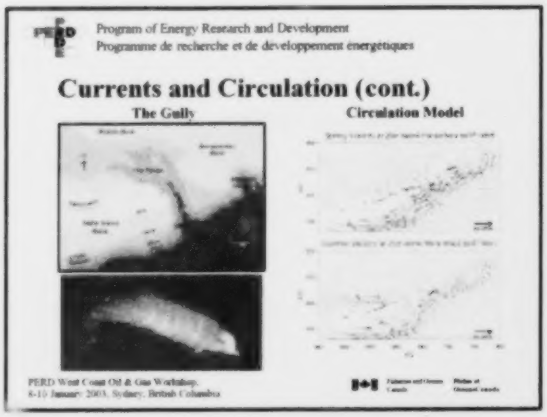

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Currents and Circulation (cont.)

The Gully **Circulation Model**

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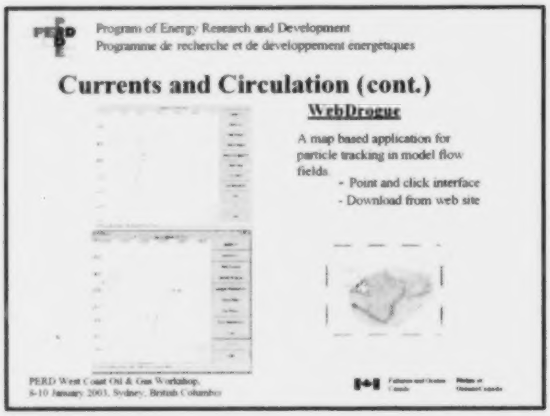

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Currents and Circulation (cont.)

WebDrogue

A map based application for particle tracking in model flow fields
- Point and click interface
- Download from web site

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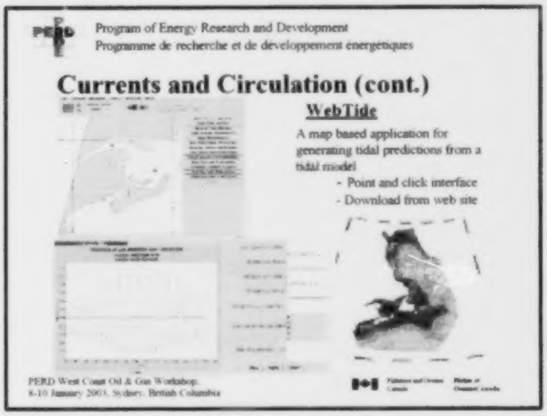

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Currents and Circulation (cont.)

WebTide

A map based application for generating tidal predictions from a tidal model
- Point and click interface
- Download from web site

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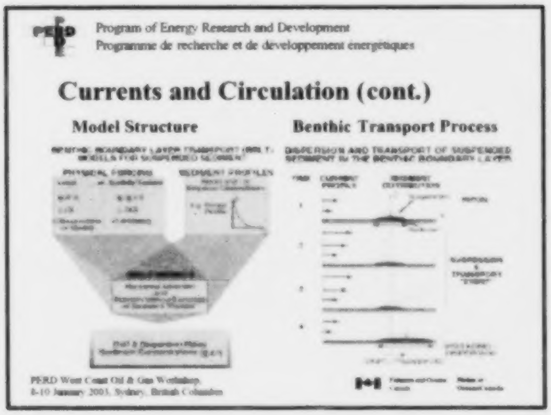

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Currents and Circulation (cont.)

Model Structure **Benthic Transport Process**

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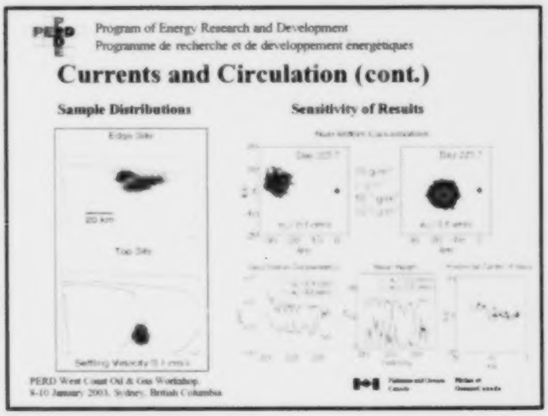

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Currents and Circulation (cont.)

Sample Distributions **Sensitivity of Results**

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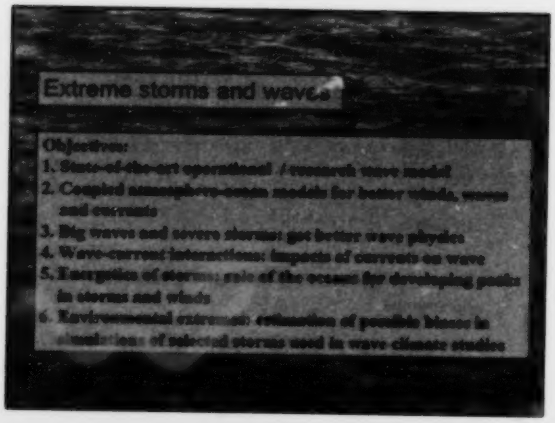
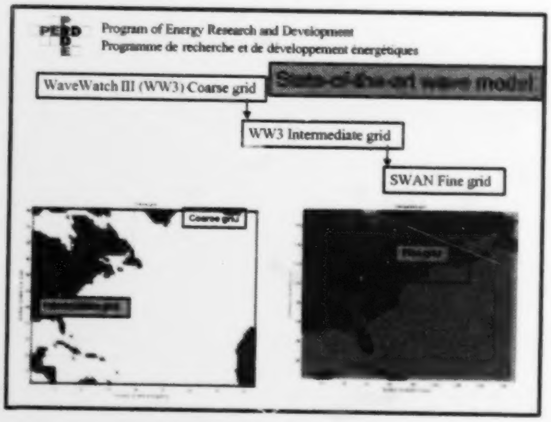


Extreme storms and waves

Objectives:

1. State-of-the-art operational / research wave model
2. Coupled atmosphere-ocean models for better winds, waves and currents
3. Big waves and severe storms: get better wave physics
4. Wave-current interactions: impacts of currents on wave
5. Energetics of storms: role of the ocean for developing peaks in storms and winds
6. Environmental extremes: estimation of possible biases in simulations of selected storms used in wave climate studies



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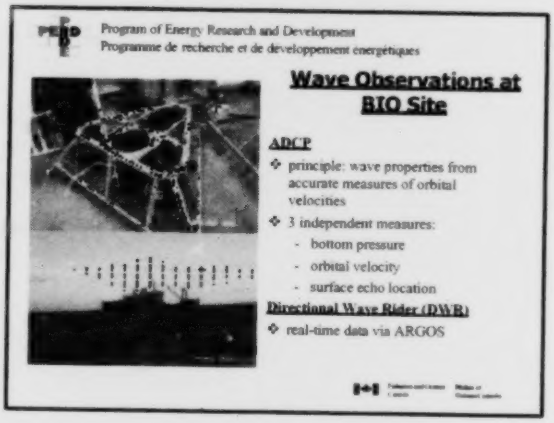
State-of-the-art wave model

WaveWatch III (WW3) Coarse grid

WW3 Intermediate grid

SWAN Fine grid



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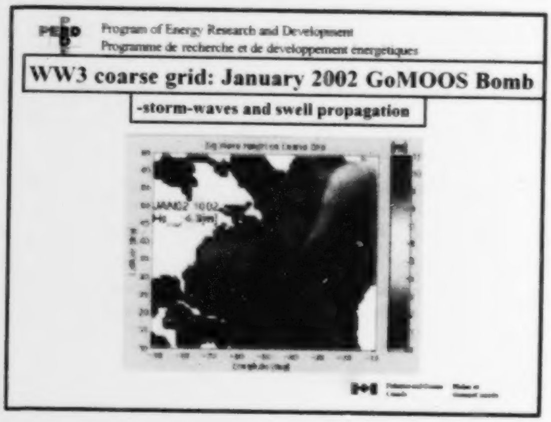
Wave Observations at BIO Site

ADCP

- principle: wave properties from accurate measures of orbital velocities
- 3 independent measures:
  - bottom pressure
  - orbital velocity
  - surface echo location

Directional Wave Rider (DWR)

- real-time data via ARGOS



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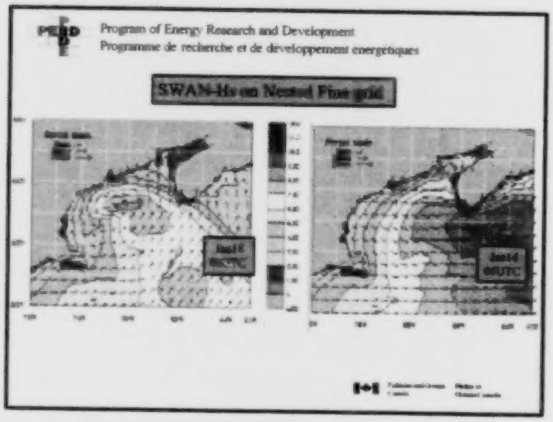
WW3 coarse grid: January 2002 GoMOOS Bomb

-storm-waves and swell propagation



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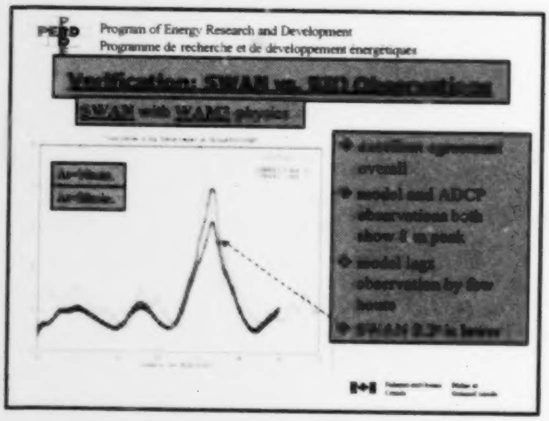
SWAN-Hs on Nested Fine grid



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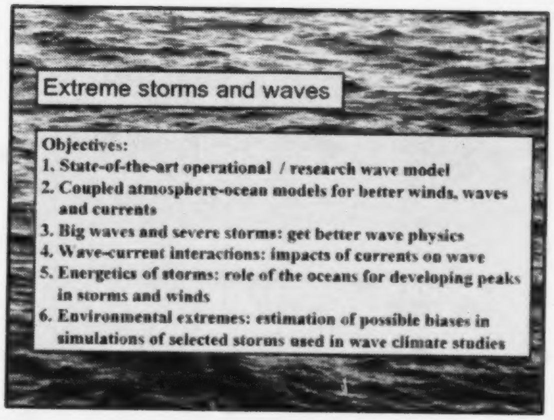
Verification: SWAN vs. BIO Observations

SWAN with WAM3 physics

- excellent agreement overall
- model and ADCP observations both show 8 m peak
- model lags observation by few hours
- SWAN 2.2 is better



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3. **Big waves and severe storms: get better wave physics**
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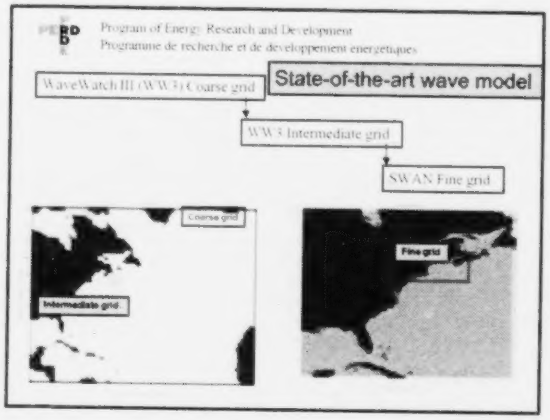

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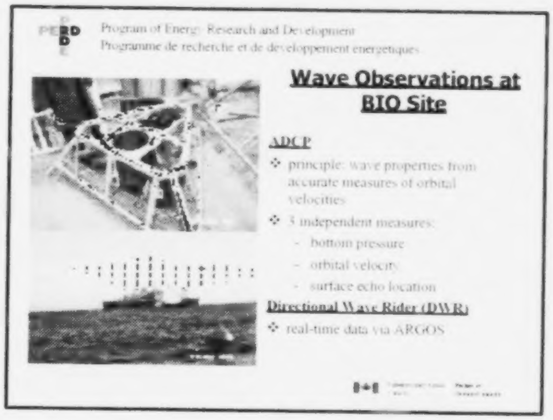
State-of-the-art wave model

WaveWatch III (WW3) Coarse grid
WW3 Intermediate grid
SWAN Fine grid



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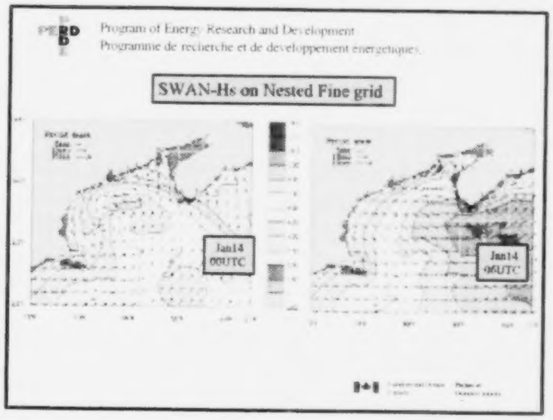

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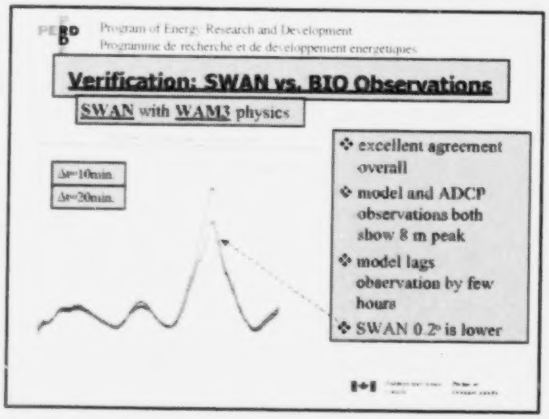
SWAN-Hs on Nested Fine grid



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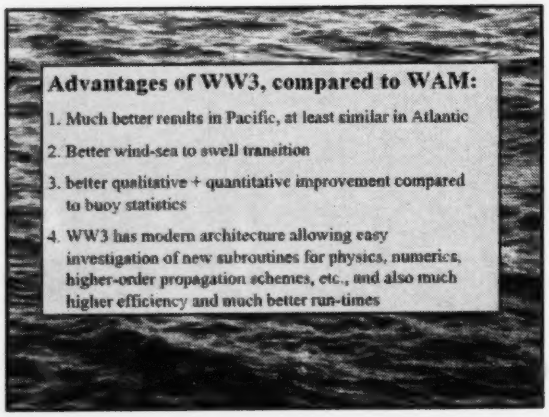
Verification: SWAN vs. BIO Observations

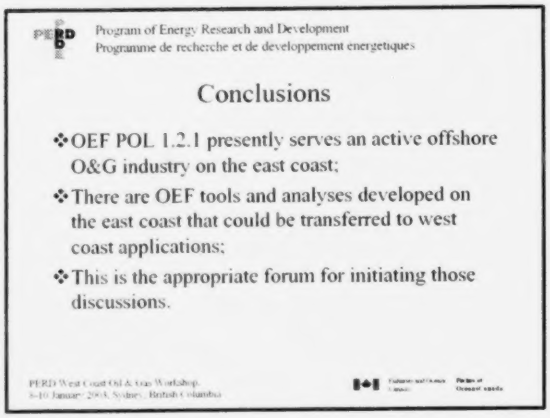
SWAN with WAM3 physics

- excellent agreement overall
- model and ADCP observations both show 8 m peak
- model lags observation by few hours
- SWAN 0.2° is lower



Advantages of WW3, compared to WAM:

1. Much better results in Pacific, at least similar in Atlantic
2. Better wind-sea to swell transition
3. better qualitative + quantitative improvement compared to buoy statistics
4. WW3 has modern architecture allowing easy investigation of new subroutines for physics, numerics, higher-order propagation schemes, etc., and also much higher efficiency and much better run-times



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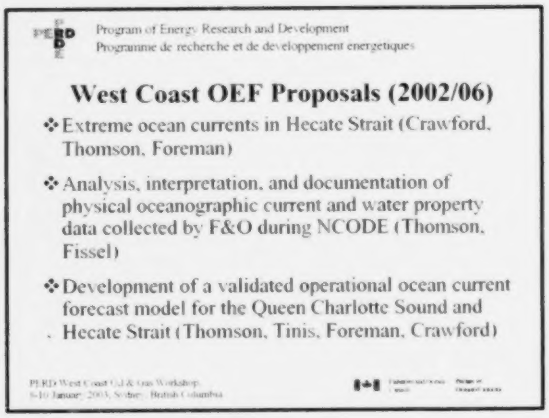
Conclusions

❖ OEF POL 1.2.1 presently serves an active offshore O&G industry on the east coast;

❖ There are OEF tools and analyses developed on the east coast that could be transferred to west coast applications;

❖ This is the appropriate forum for initiating those discussions.

PERD West Coast Oil & Gas Workshop.
8-10 January 2003, Sydney, British Columbia



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West Coast OEF Proposals (2002/06)

❖ Extreme ocean currents in Hecate Strait (Crawford, Thomson, Foreman)

❖ Analysis, interpretation, and documentation of physical oceanographic current and water property data collected by F&O during NCODE (Thomson, Fissel)

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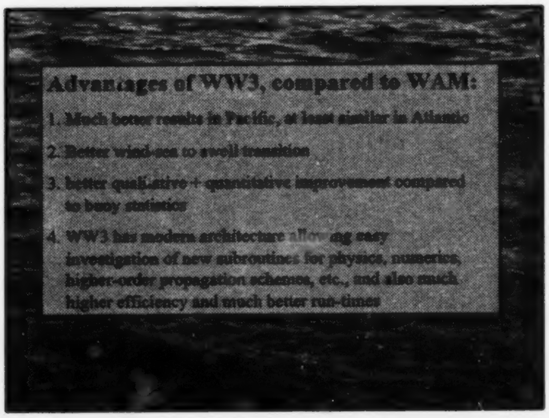

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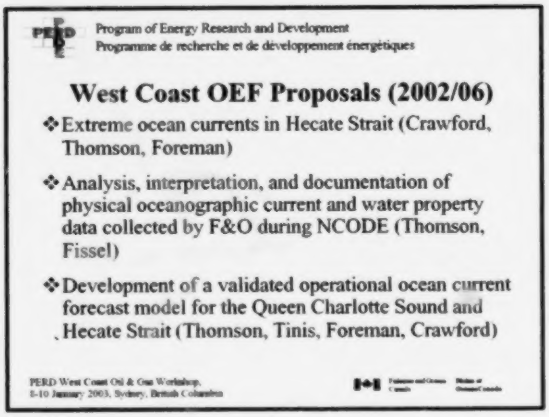

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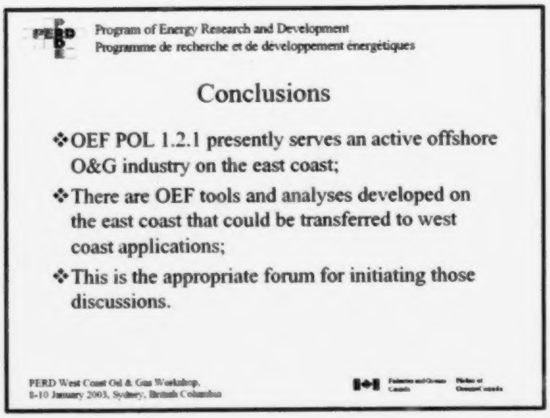

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Discussion

Bottom mounted wave sensors are really made for shallow water. The sensor was at 19 m, they would not work at 100 m. One using a higher frequency would work, but would not get as much resolution. Bottom pressure sensors would not be usable. The sensor was 1.2 MHz. 600 KHz actually works at 80 m (Woods Hole) with reasonable results. The two spectra from the bottom pressure and the orbital velocities agreed very well throughout the entire record. The surface echolocation is a bit fuzzy.

The East Coast "bomb" did not affect the offshore rigs as maximum waves occurred near shore.

PERD Wave and Marine Wind Projects 2002/03

OEF Wind and Waves Research

V. Swail

Environment Canada

PERD WAVE AND MARINE WIND PROJECTS 2002/03

12100A01	MSC	Offshore Wind and Wave Design Criteria
12100A03	MSC	Data Assimilation into Coupled Atmosphere-Ocean Wave Models
12100A04	DFO /MSC	Extreme Storms and Waves
12100A02	MSC	Validation of Buoy and Platform Wind and Wave Measurements
12100A05	DFO	Hydrodynamic Loads on Slender Structures
12100A06	DFO	Field Evaluation of Ocean Wind and Wave Estimates by Satellite-Borne and Marine Radar Systems

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Appendix A – Resources

2001–2002 Resource Summary

POL 1.2.1

Funding Sources	
Organization	*Funds ($K)*
PERD – A. Wind and Waves	550
A-Base (list $ by department)	
EC	170
DFO/CCG	20
CHS	20
CCRS	10
Industry (list companies)	
Int'l Oil and Gas Prod. (OGP)	50
Oceanweather	25
Other (specify)	
CBLAST	10
GoMOOS	80
Canadian Space Agency	11
US Army Eng R&D Center	50
Southampton Oceanography	60
Dalhousie	8
Oxford University	5
CFCAS	15
TOTAL	1081

Outputs

A1: Development of Improved Wind-Wave Hindcasts

➢North Atlantic 43-year wind-wave hindcasts

➢Wind and wave scenario modelling to the year 2100.

➢Wave design criteria determination based on satellite altimeter data.

➢MSC40 web page containing project description, validation results and extremal analysis

➢7th International Workshop on Wave Hindcasting and Forecasting;
  ➢coincident hosting of International Oil and Gas Producers (OGP) meeting, Oct. 17-25, 2002
  ➢www.oceanweather.com/7thwave

A2: Development and Assessment of Instruments and Techniques for Wind, Wave

➢Assessment of methods for monitoring marine winds and waves, - buoys, ships

➢Presentation of results to WMO Data Buoy Cooperation Panel meeting

---

A3: Testing and Validation of New Data and Techniques for Forecasting and Monitoring

➢Improved physics in state-of-the art wave models, including atmospheric boundary layer-ocean coupling and feedback mechanisms, wave breaking and dissipation

➢Evaluation of CMC regional wave forecasting system, intercomparison of operational wave forecasting systems, and shallow water intercomparison of wave models on Lake Erie

➢Evaluation of high resolution and nested versions of the WAM in collaboration with MSC Atlantic

➢Initial implementation and wave height simulations using high resolution and nested versions of WAM, Wavewatch-III and SWAN models nested with high resolution WAM for 2 recent extreme storms

➢coupled atmosphere-ocean wave model: MC2 mesoscale atmosphere model and WAM ocean model

➢Investigated Canadian regional climate model CRCM, to simulate storms; coupling atmosphere-wave-oceanic models can give >10% effects on wave heights in high storm conditions

➢Developed improved computer codes for wave-wave interactions

➢Analysis wave model sensitivity to currents, shows currents important (>10%) in high current conditions

➢Show wave impacts on surface currents during storms can be ~ 40% of the current magnitudes

➢New computer coding of the heat flux effects of sea spray

➢Calibrate high-resolution (<5km) RADARSAT SAR wind fields for severe storm, hurricane conditions

➢A1-A3 total: Results disseminated to scientists and industry through series of publications – 36

Outcomes

A1: Application of Wind and Wave Hindcast Results

43-year database of high-quality continuous wind and wave hindcasts has been used extensively by industry in several east coast offshore projects during the year, including Petro-Canada, Pan Canadian, Exxon/Mobil, Chevron/Texaco, BP, Marathon and Shell, and by regulatory authorities in several Environmental Assessments.

Hindcast data base and statistics used by DFO-MEDS in wave climate program

Hindcast data base and statistics used by Canadian Coast Guard in Search and Rescue R&D program

Hindcast data base and statistics provided to R&D projects in PERD Climate Change Impacts on the Energy Sector POL

A3: Application of Improved Wind-Wave Models for More Accurate Operational Forecasts

MSC is significantly increasing the resolution of their wave model grid.

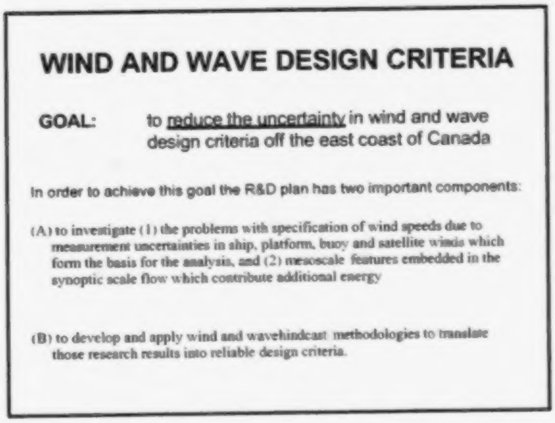
MSC and BIO have established a new cooperative research program to extensively compare the WAM model that is used operationally with newer models such as WW3 and SWAN.

Industry consultants have entered a partnership with BIO-MSC in testing new models, SWAN, at high resolution implementations, for areas around hydrocarbon sites.

Wave model intercomparison results are used by international centers to identify areas of potential improvements of various operational ocean wave forecasting systems (winds and waves), as part of a WMO program

Nested versions of WAM are being used by the Atlantic Region to produce more accurate ocean wave forecasts for the Northwest Atlantic.

Monitoring of wave model performance has led to the identification of a possible incorrect implementation of the WAM Cycle-4 in the international near shore SWAN model.



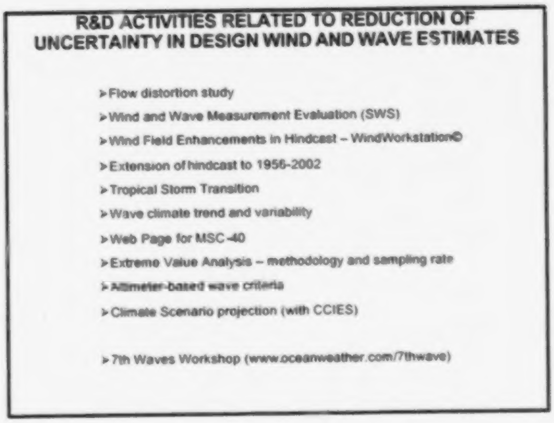
WIND AND WAVE DESIGN CRITERIA

GOAL: to reduce the uncertainty in wind and wave design criteria off the east coast of Canada

In order to achieve this goal the R&D plan has two important components:

(A) to investigate (1) the problems with specification of wind speeds due to measurement uncertainties in ship, platform, buoy and satellite winds which form the basis for the analysis, and (2) mesoscale features embedded in the synoptic scale flow which contribute additional energy

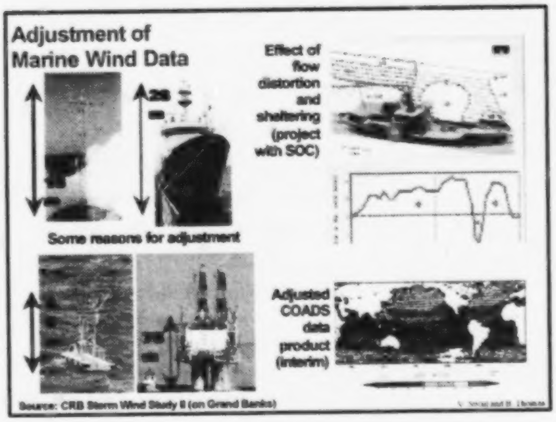
(B) to develop and apply wind and wavehindcast methodologies to translate those research results into reliable design criteria.



R&D ACTIVITIES RELATED TO REDUCTION OF UNCERTAINTY IN DESIGN WIND AND WAVE ESTIMATES

- Flow distortion study
- Wind and Wave Measurement Evaluation (SWS)
- Wind Field Enhancements in Hindcast – WindWorkstation©
- Extension of hindcast to 1956-2002
- Tropical Storm Transition
- Wave climate trend and variability
- Web Page for MSC-40
- Extreme Value Analysis – methodology and sampling rate
- Altimeter-based wave criteria
- Climate Scenario projection (with CCIES)

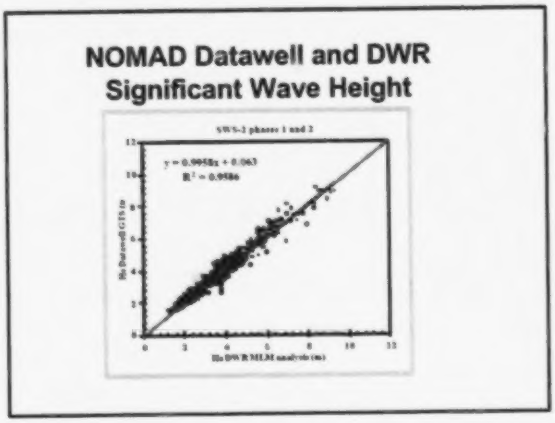
- 7th Waves Workshop (www.oceanweather.com/7thwave)



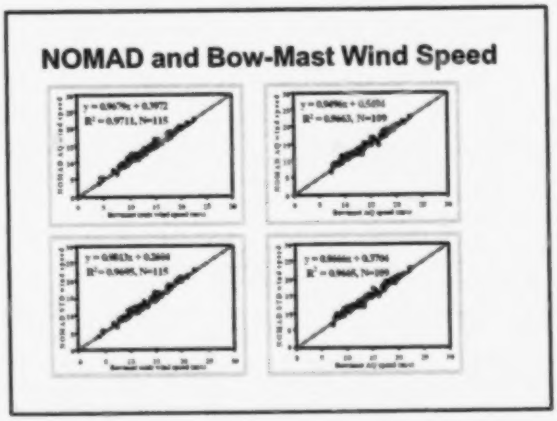
Adjustment of Marine Wind Data

28 m
Some reasons for adjustment
Effect of flow distortion and sheltering (project with SOC)
Adjusted COADS data product (interim)

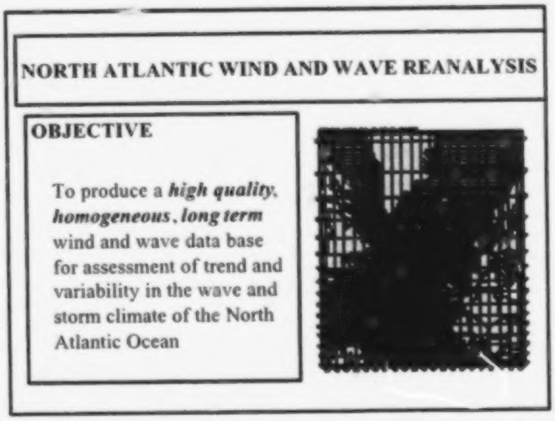
Source: CRB Storm Wind Study II (on Grand Banks)



NOMAD Datawell and DWR Significant Wave Height



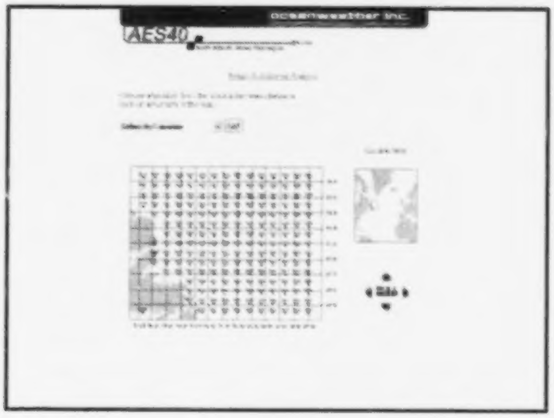
NOMAD and Bow-Mast Wind Speed

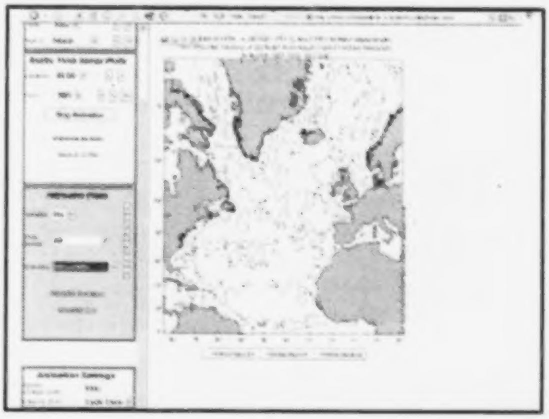


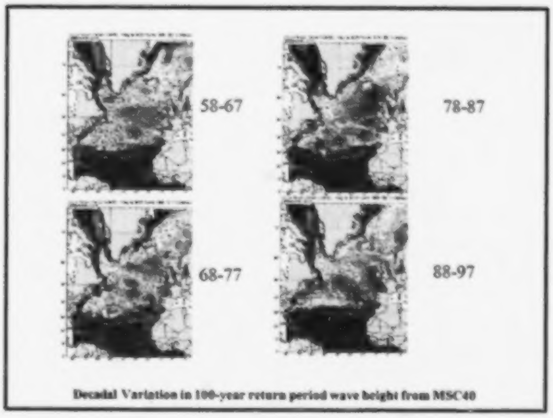
NORTH ATLANTIC WIND AND WAVE REANALYSIS

OBJECTIVE

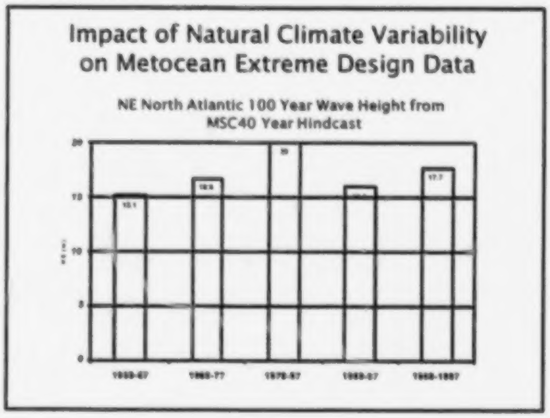
To produce a ***high quality, homogeneous, long term*** wind and wave data base for assessment of trend and variability in the wave and storm climate of the North Atlantic Ocean

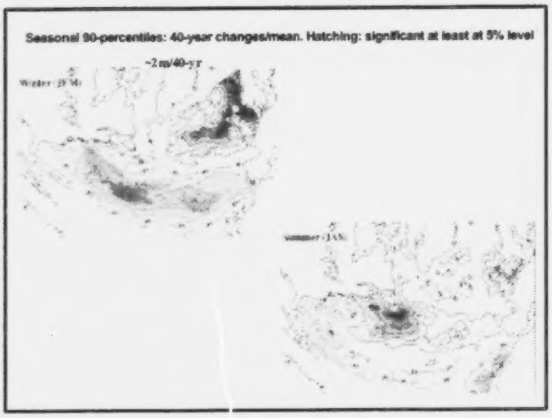




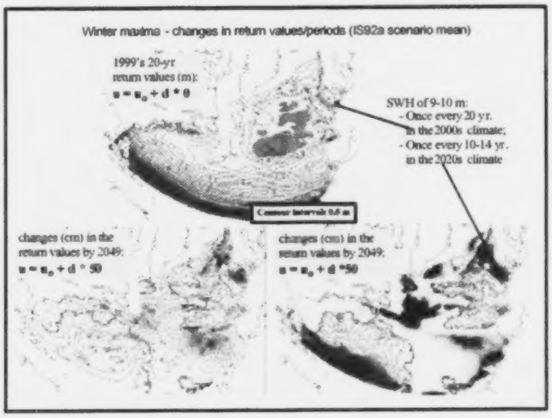


Decadal Variation in 100-year return period wave height from MSC40



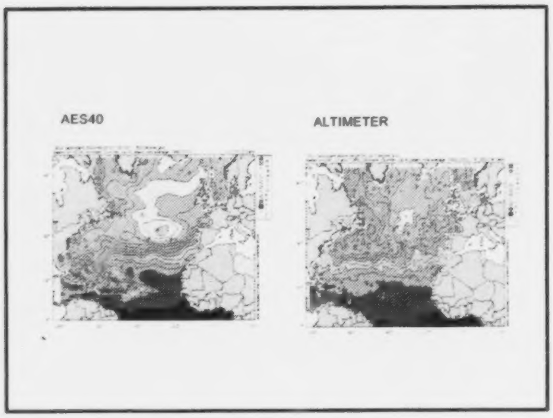


Seasonal 90-percentiles: 40-year changes/mean. Hatching: significant at least at 5% level



Winter maxima - changes in return values/periods (IS92a scenario mean)

SWH of 9-10 m:
- Once every 20 yr. in the 2000s climate;
- Once every 10-14 yr. in the 2020s climate



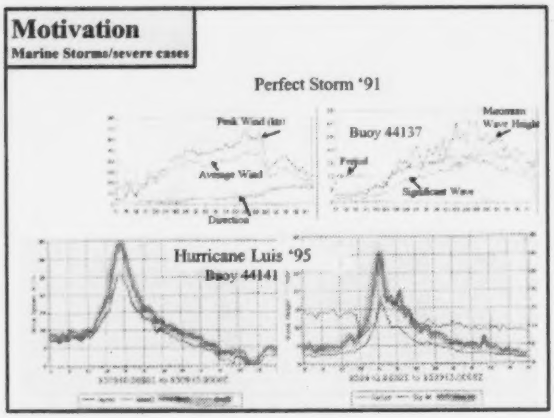
FUTURE R&D ACTIVITIES IN DESIGN WIND AND WAVES INCLUDE THE FOLLOWING

- Kinematic Wind Field Enhancements in Hindcasts especially in extreme storms
- More timely updating of recent years – issues with NHC
- Extension of hindcast to 50 years
  - on finer scale grid, down to 0.1 degrees, at least in nests
  - Incorporating shallow water effects
  - On 1-hour time scale
  - Saving 2-D spectra at every grid point
  - Timing depends on potential industry partnerships – Shell, Marathon, Exxon/Mobil, Chevron

Waves on Sable Island Bank and the Grand Banks

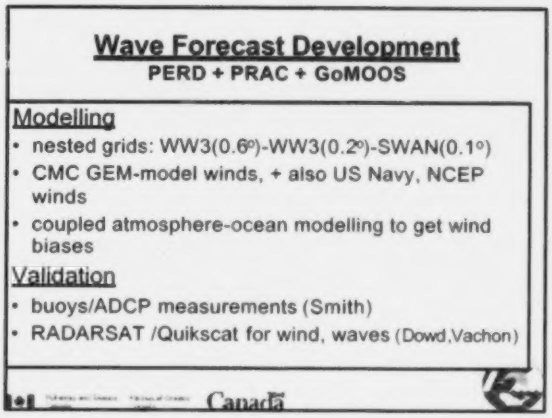
Objectives

1. Implement and test models for routine high resolution wave forecasts, including shallow water and currents.
2. Investigate extreme waves for Scotian Shelf, the Grand Banks and related Atlantic Canada areas - test new science
3. Document biases and limitations in wave models and recommendations related to potential implementation.



Motivation

Marine Storms/severe cases



Wave Forecast Development

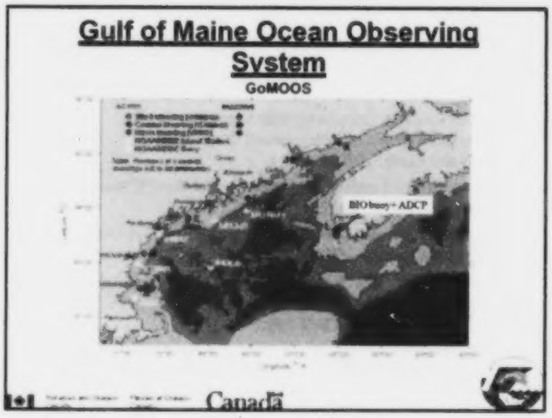
PERD + PRAC + GoMOOS

Modelling

- nested grids: WW3(0.6°)-WW3(0.2°)-SWAN(0.1°)
- CMC GEM-model winds, + also US Navy, NCEP winds
- coupled atmosphere-ocean modelling to get wind biases

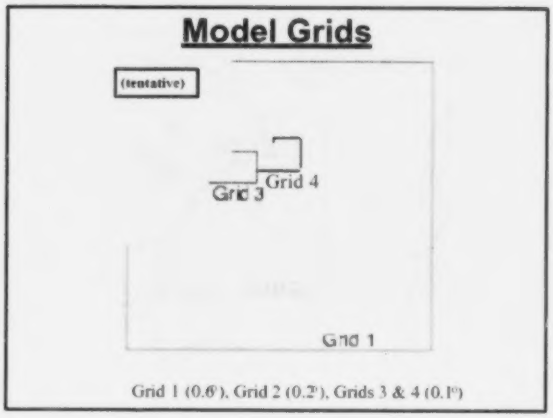
Validation

- buoys/ADCP measurements (Smith)
- RADARSAT /Quikscat for wind, waves (Dowd,Vachon)



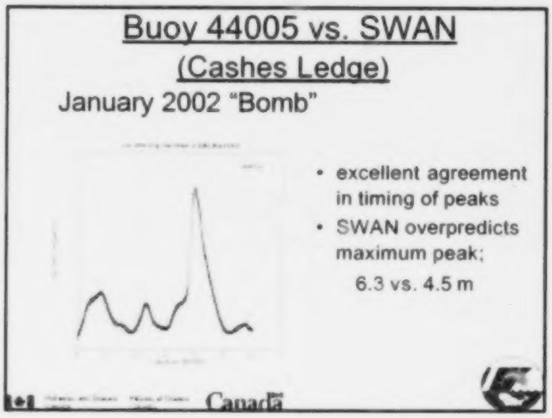
Gulf of Maine Ocean Observing System

GoMOOS



Model Grids

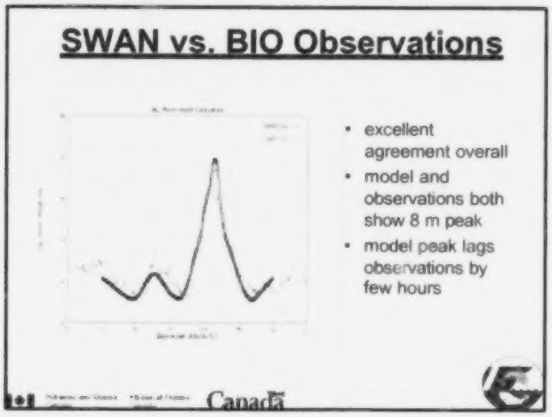
Grid 1 (0.6°), Grid 2 (0.2°), Grids 3 & 4 (0.1°)



Buoy 44005 vs. SWAN (Cashes Ledge)

January 2002 "Bomb"

- excellent agreement in timing of peaks
- SWAN overpredicts maximum peak;
  6.3 vs. 4.5 m



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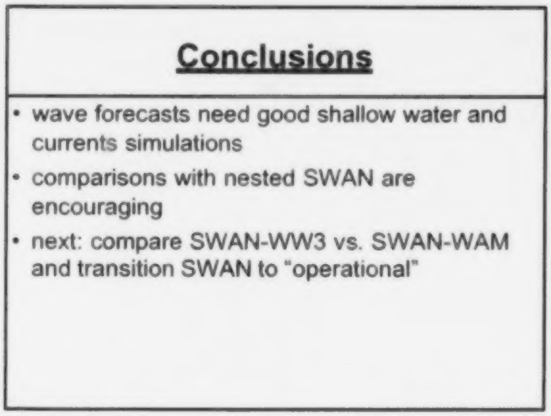


Conclusions

- wave forecasts need good shallow water and currents simulations
- comparisons with nested SWAN are encouraging
- next: compare SWAN-WW3 vs. SWAN-WAM and transition SWAN to "operational"

PREVIOUS WEST COAST STUDIES

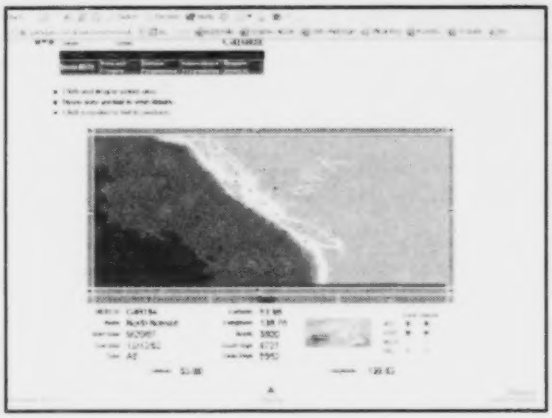
- Wave Climate Study – Northern Coast BC - ESRF 1987
- Environmental Criteria for Canadian waters: An Assessment of Data Resources and Design Requirements – PERD 1991
- Wind/Wave Hindcast Extremes for the West Coast of Canada – PERD 1992
- Wind and Wave Climate Atlas – Volume 4 The West Coast of Canada – TDC/SAR 1993
- Verification of Wave Models Output Versus Measured Wave Data for the Great Lakes, East and West Coasts of Canada – PERD/SAR 1995
- A Global Wave Hindcast over the Period 1958-1997: Validation and Climate Assessment – PERD/MSC 2001

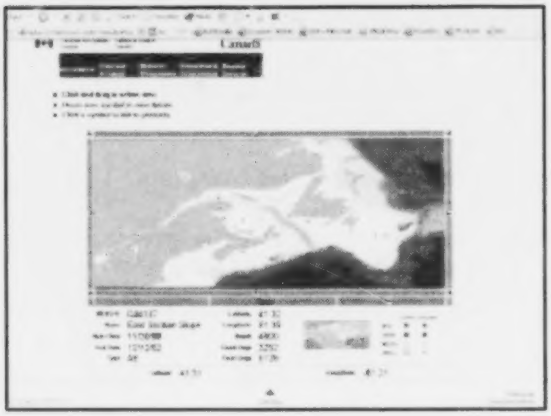
PARTIAL LIST OF WIND AND WAVE R&D NEEDS – WEST COAST

- Implementation, testing and evaluation of wave model developments for WC (WAM, WW3, SWAN in various configurations)
- Evaluation and implementation of Regional Atmospheric Model for coastal wind fields: (GEM)MC2, REMO
- Evaluation of CMC operational wave forecast system for WC, and implementation of improved model
- Assimilation of satellite winds into operational wave forecast system – 3DVAR or 4DVAR
- Update and upgrade WC wind/wave hindcast to level of NA hindcast (partners in waiting – US Army, US Navy, OGP)

THE END

OR, THE BEGINNING...





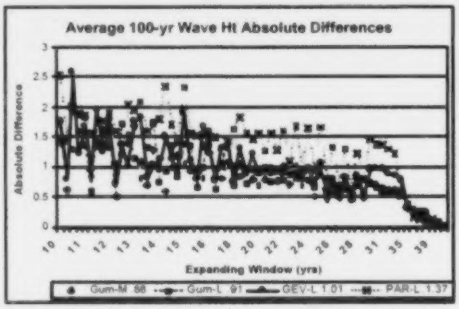
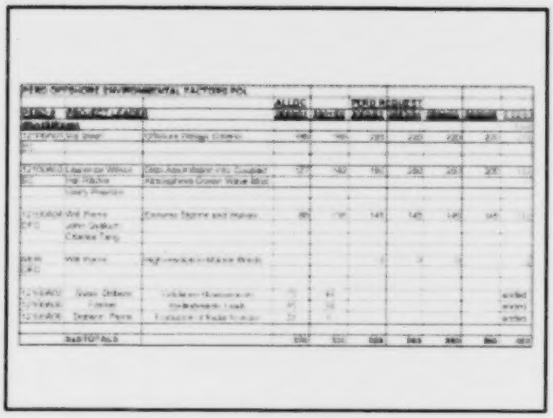


Figure 4. Absolute difference (m) between 100-year wave height computed from 41-year sample and that computed from the expanding window ranging from 10-40 years.



Discussion

Upgrading to the level of the North Atlantic model means using kinematic analysis. At this point, hindcast results that do not include kinematic analysis are not going to receive credibility from the oil and gas industry, the classification societies or the regulators. They all know that none of the model outputs catch the peak condition. The material presented at Banff and the comparisons with even the ECWF analysis could not match what was put into our kinematic analysis in the North Atlantic hindcast.

For areas where kinematic analysis would be most important, there is less of a data void on the West Coast than the East Coast. Unlike the East Coast buoys, the West Coast buoys tend to stay in place.

Weather buoys tend not to measure extreme waves and peaks. Five years ago, it was suggested that the software be changed to go from ± 15 to ± 20 but it is not sure if this was done. It is very difficult to measure individual waves so there is more uncertainty in the extreme wave measurement than there is in the significant wave measurement. This is why industry does not put a lot of stock in the measurement and why the American agency does not even produce that number. People would prefer to take the significant wave in which they have a lot of confidence and use the statistical relationship of 1.86 (or whatever they want) to come up with the maximum wave.

People have been fighting with the problem of measuring extreme waves for a long time and it is not easy. How does one define a wave and where does it stop? Fifty percent foam can still have significant force. It is not something industry has identified as a concern. It was supported as an issue initially, but after three years it was decided that other things were a higher priority.

Adapting models that are largely for offshore and open oceanic areas to Hecate Strait with its bathymetry and topography is not that difficult an issue. It is necessary to have the appropriate grid resolution and topography in the model. Currents are also an important factor. On the East Coast, the model has been applied to the Gulf of Maine with the inflow and outflow of the Bay of Fundy so the situation is not unique to British Columbia. A European project used the regional atmospheric model and fine resolution and either the SWAN or WAM. Other than a few hills in the area between the U.K., Netherlands and Germany, there is not a lot of difference with the West Coast. The mesoscale models are coming along nicely. The US Navy is doing a lot of model work all over the world. We do not need to start from zero but we will need appropriate data.

PERD Funded, NRCan S&T Applicable and/or Transferable to the West Coast

Overview of East Coast Marine Geoscience Activities with Possible West Coast Application

S. Blasco

Natural Resources Canada

PERD FUNDED NRCAN S&T APPLICABLE / TRANSFERABLE TO THE WEST COAST

PERD POL PLANS

- OFFSHORE ENVIRONMENTAL FACTORS
- NORTHERN HYDROCARBON PRODUCTION
- PIPELINE

S&T PROCESS PARTNERSHIPS

- A-BASE
- OTHER POLS
- INDUSTRY
- REGULATORS
- UNIVERSITIES
- PROVINCE
- FIRST NATIONS

S&T PROCESS CONSULTATION

- PROJECT DEFINITION
- PROJECT ASSESSMENT
  - PARTNERS
  - REGULATORS
  - FIRST NATIONS

GEOSCIENCE ISSUES

- GEOTECHNICAL
- GEOHAZARDS
- ENVIRONMENTAL
- BASIN ASSESSMENT

SEABED STABILITY

- FOUNDATION CONDITIONS
- SEDIMENT TRANSPORT
- SLOPE FAILURES

GAS HYDRATES SHALLOW GAS

- MAPPING TECHNIQUES
- PROPERTIES

HABITAT SENSITIVITY & MARINE PROTECTED AREAS

- TECHNOLOGY
- METHODOLOGY
- PARTNERSHIPS: DFO, FIRST NATIONS, PROVINCE, FISHERIES

NEW SURVEY TECHNOLOGIES

- ENVIRONMENTAL IMPACT OF MULTIBEAM SONARS AND INTERFEROMETRIC SIDESCANS

PIPELINES

- SLOPE STABILITY: NE BC
- SOIL-PIPE INTERACTION RISK ASSESSMENT
- ROUTING AND MONITORING

BASIN ASSESSMENT

- NEW TECHNOLOGIES & METHODOLOGIES
- APPLICABLE TO NEW DATA ONLY

KEY ISSUES

- IMPORTANCE OF HISTORIC DATA
- DATED DATA
- PARTNERSHIPS
- TAKE ADVANTAGE OF PERD ADVANCES

Discussion

New money ($35 million to universities and $2 million to government labs) for offshore oil and gas research in the arctic has come from the Government of Canada. Getting money for Beaufort Sea activities was a huge challenge because departments were very reluctant to go ahead with it, as Cabinet would simply tell them to reallocate funds. After a year of making it clear to Cabinet and the Privy Council Office that reallocation is not an option due to lack of available funds, some resources were obtained. Some of the federal budget surplus was transferred to foundations where departments no longer had direct control. For example, $400 million was allocated to the Canadian Foundation of Innovation (CFI). Historically, once Cabinet approval for programs was obtained, it was a matter of time before Central Agencies approved it and put it in place. This has shifted such that everything Cabinet approves goes to the Central Agencies.

It is important for the university system and the federal government system to move together rather than at the expense of one another. We have to recognise that the Government of Canada now sees fundamental research as belonging in the university environment so we need to take advantage of it. We have options and the West Coast can surely take advantage of it under this new approach. In some cases, the money is Natural Sciences and Engineering Research Council (NSERC) funding going to a large group of academics. They have previous programs and they have moved resources to those areas. They can move that money if there is a good reason to do so. It is a large group and they move it where they think there is scientific interest. Feedback from NSERC indicates that the Government of Canada will continue to put millions into the university environment over the next decade and it is uncertain if that will be at the expense of the federal government system. We need to be there as partners and make it work. We have to be a bit innovative about how we deal with it.

In regards to PERD, it was understood we were not to bother going forward with a major arctic research initiative if they were required to look for any new money. They went back to the drawing board with the approach to recommend that a strategic environmental assessment be done on the West Coast. It is uncertain if there was a price tag attached for research funds. Departments were asked to see what they could do within their system allocations. Central Agencies said that any proposal going forward to Cabinet cannot have funding attached so it has been significantly redone. This was one of the reasons the Director General of the Office of Energy Research and Development (OERD) wanted this group to get together at this workshop. Also, the PERD POL leaders got together in October and took a look at the funding requirements for all the work if we are asked to go forward with this and there is no new money. We are going to have to dig into our own pockets and making some really hard decisions about where we are going to get the money.

The exercise that we are going through in this workshop is to prioritise what needs to be done as quickly as possible and what can wait a bit. It is going to be really important in terms of going back to Ottawa and saying this is what we have come up with in this workshop and this is how it is going to impact PERD. The universities are in a much better position than the federal labs, so

Government of Canada can go forward to Treasury Board with a parallel proposal. We might win that way because then they will see that we are really linked. We need a clear understanding of what we are doing in the federal government system and in the universities and how we are working together. Universities have done a good job of lobbying and have done well by it.

NRCan has been told that science done in the department will be that needed for policy development, public safety, public health and sustainable development. That is what the Government of Canada will concentrate on and that will be the mandate. If scientists want to do fundamental research they are going to find themselves in the university setting. This is a huge issue in NRCan now. Scientists need to know this because they may be frustrated in government doing applied research when they have the talent to solve fundamental issues such as the university does. We need to determine what is needed to solve a problem associated with the moratorium versus the fundamental research we need over time at the universities. Another concern is monitoring, if it is not done in government or in the universities, it gets lost in the system. It would be unfortunate if the West Coast lost out as occurred in the Arctic. We were excited about $1 million but it did not compare with the $34 million. $27.7 million came out of the renovation fund and $10 million from NSERC. NSERC money may have been new money or reallocated funds. They are now considering an additional $10 million of new money for Beaufort Sea activities so they are moving ahead in the university environment.

The ownership of the *Franklin* was a huge issue under the CFI rules where the universities must own the resource. After discussion, it was considered that it was not cost-effective for the university to take over the icebreaker and manage the crew and so on. An exemption was given in this case and the vessel remained under the Canadian Coast Guard. The $27.7 million was applied to modify the *Franklin* for scientific research. It will be used for six months in the Arctic and will be available for Coast Guard to use on other duties such as icebreaking for the other six months. DFO has been instrumental in helping this system work. There is expectation that the vessel will stay in the science community for seven or eight years, assuming subsequent programs. The universities will go through a steep learning curve but will do fine. There is lots we can help with in terms of the science, logistics, information and knowledge we have of the north, and we can make it work for both of us.

PERD Program at Objective Level 1.2.4: Environmental Impacts of Offshore Oil and Gas Activities

H. Bain
Fisheries and Oceans Canada

PERD Program at Objective Level 1.2.4

Environmental Impacts of Offshore Oil and Gas Activities

Hugh Bain and Kenneth Lee
Fisheries and Oceans Canada

Program Management Structure

- Management by Objective: i.e. *Program at the Objective Level (POL)*
  - – 6 Strategic Intents
  - – 14 Strategic Directions
  - – 42 Objectives

Strategic Intent (1)

Fulfill federal government responsibilities while maximizing economic benefits and reducing environmental consequences from the expansion and diversification of Canada's oil and gas production.

Strategic Direction (2)

Provide S&T to extend and diversify Canada's oil and gas production from offshore and northern regions through the development of the science and technology needed for standards and regulations, and to reduce costs and mitigate environmental and safety concerns.

Objective (4)

Regulatory requirements for offshore drilling and production wastes, assessment of cumulative effects, and remediation of offshore discharges and spills.

Research Activities:

A Plan at Objective Level (POL) research program for:
- Assessment of environmental impacts and risks
- Scientific knowledge to support regulatory guideline improvements
- Development of oil spill countermeasures

Primary program focus:
- Drilling Wastes
- Produced Water
- Remediation of accidental offshore discharges and spills

A Quantitative Assessment Model for the Fate and Environmental Effects of Drilling Wastes

To improve predictive models for assessing impacts of drilling wastes on benthic and demersal organisms and populations

- extend and increase the availability of the benthic dispersion (bblt) model
- obtain information on the flocculation/settling dynamics and vertical distribution of drilling waste components
- develop a generic module with exposure effects data for evaluating potential impacts on organisms and populations
- model calibration/ validation with SOEI EEM program
- Extension of operational use to the West Coast and Arctic

Risks of Offshore Development on Crab and Shrimp Resources

The crab and shrimp fisheries are of major economic importance in the Newfoundland and Quebec Regions.

Determine if oil development poses a risk to these important resources:

- **Chronic toxicity studies with synthetic drilling fluids, bentonite/barite, and petroleum hydrocarbons as well as authentic sediments**
- **Dose-response studies to assess potential for contamination of market products.**
- **Scientific framework for use in policy decisions on whether risks to crab and crab habitat warrant management attention under the *Fisheries Act***

Example of a Project Deliverable on the Application of EEM Results

Sediment toxicity, is frequently assessed by the Microtox assay in EEM programs in the offshore.

Concerns have been expressed on whether this toxicity is due to synthetic drilling fluid or its degradation by-products.

PERD/ESRF studies over the past two years have established that the observed toxicity is not due to the toxicity of drilling fluid, but is more likely associated with random anaerobiosis which is natural in sediments.

Ecological Risk of Produced Water Discharges

Future production water discharges may impact the biota (invertebrates, fish and larvae) at distances greater than originally envisaged.

An objective study in the Atlantic Region is required to:

- Characterize produced waters in the Atlantic Region
- Determine dose response levels
- Determine the processes controlling the transport of produced water contaminants
- Developmemt of predictive models on transport pathways of contaminants and sub-lethal effects
- Provide an ecological risk assessment for resource managers to resolve potential conflicts that may obstruct offshore energy development

Remediation of Accidental Offshore Discharges and Spills

Marine transport including sub-sea pipelines are the principal methods of transporting crude oil and its refined products to market within Canada.

Public acceptance of the offshore industry is tempered by concerns over ecological damage from oil spills.

Remediation of Accidental Offshore Discharges and Spills

PERD has been a primary supporter of Canada's research programs on oil spill impacts and countermeasures.

Studies have been focused on Canadian issues (e.g., biodegradation studies on Hibernia/Terra Nova waxy crude oils and Condensate from the Scotian Shelf.

Research programs maintain scientific expertise and laboratory facilities for use in emergency response operations.

Fate and Effects of Chemically Dispersed Oil

To determine the fate and effects of chemically dispersed oil and its potential effects on biota over several trophic levels, including commercial species of interest

Assessment of the net environmental effects of using chemical oil dispersants

- Provision of scientific knowledge to refine the dispersant use guidelines/policy in Canada
- Data on chronic effects of low-level hydrocarbon exposure for use in risk assessment models

Toxicity Identification and Evaluation (TIE) of Toxic Components in Residual Oil

A continuing debate remains over the environmental persistence and biological effects of residual oil from spills at sea.

Chronic exposure to polycyclic aromatic hydrocarbons (PAH) may impair the development of fish embryos and reduce population fitness over multiple generations.

Data linking developmental effects to the alkyl–PAH "fingerprint" of crude oils will improve our ability to assess the ecological risks of oil spills in aquatic environments

Provision of a cost effective and environmentally sound protocol for improved oil spill response strategy selection and resource damage assessments

Value of PERD Studies

PERD studies are used extensively to provide advice to Habitat Management, the Boards and industry on environmental assessments and monitoring programs.

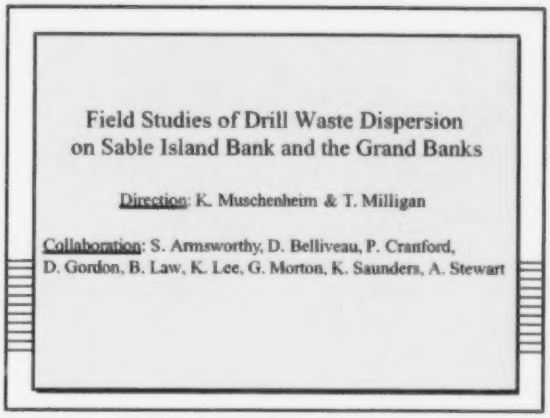
PERD studies have provided a scientific framework of key importance for DFO's input into the development of the new "Offshore Waste Treatment Guidelines".

PERD studies on oil spill remediation have resulted in the application of new technologies and operational guidelines for their use.

Field Studies of Drill Waste Dispersion on Sable Island Bank and the Grand Banks

K. Muschenheim

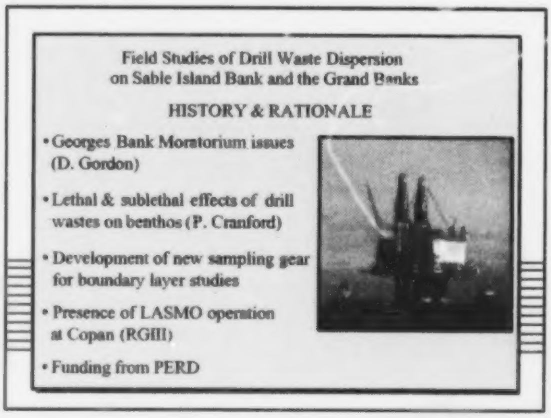
Bland Research Applications



Field Studies of Drill Waste Dispersion on Sable Island Bank and the Grand Banks

Direction: K. Muschenheim & T. Milligan

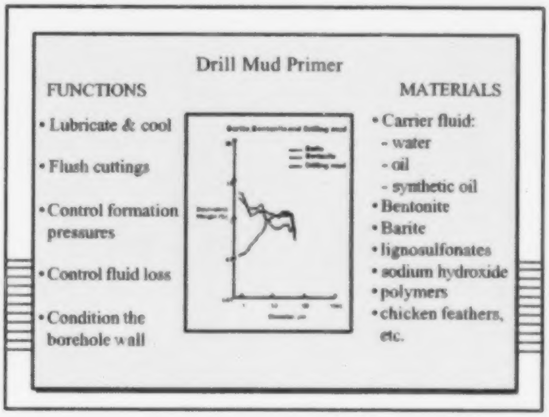
Collaboration: S. Armsworthy, D. Belliveau, P. Cranford, D. Gordon, B. Law, K. Lee, G. Morton, K. Saunders, A. Stewart



Field Studies of Drill Waste Dispersion on Sable Island Bank and the Grand Banks

HISTORY & RATIONALE

- Georges Bank Moratorium issues (D. Gordon)
- Lethal & sublethal effects of drill wastes on benthos (P. Cranford)
- Development of new sampling gear for boundary layer studies
- Presence of LASMO operation at Copan (RGIII)
- Funding from PERD



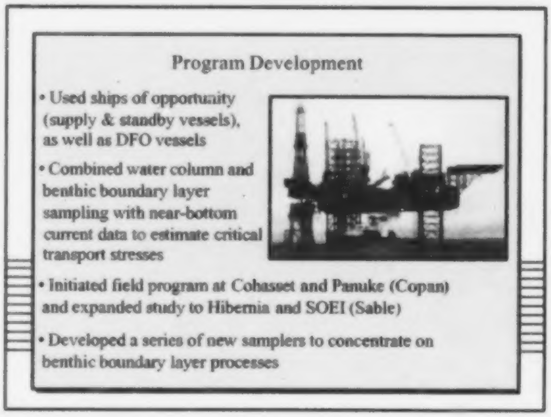
Drill Mud Primer

FUNCTIONS

- Lubricate & cool
- Flush cuttings
- Control formation pressures
- Control fluid loss
- Condition the borehole wall

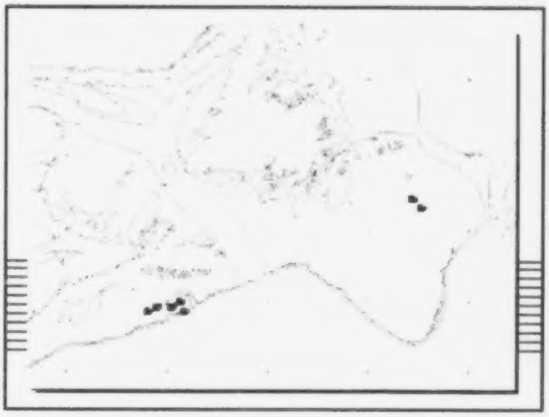
MATERIALS

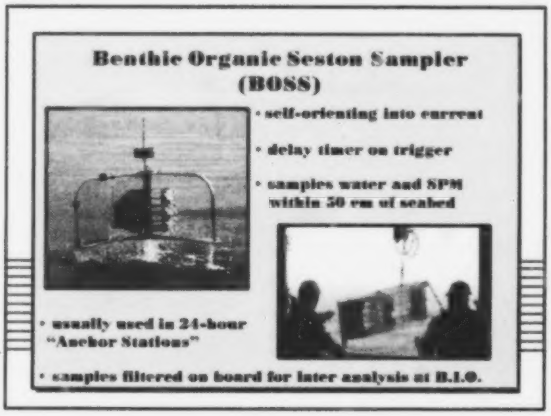
- Carrier fluid:
  - water
  - oil
  - synthetic oil
- Bentonite
- Barite
- lignosulfonates
- sodium hydroxide
- polymers
- chicken feathers, etc.



Program Development

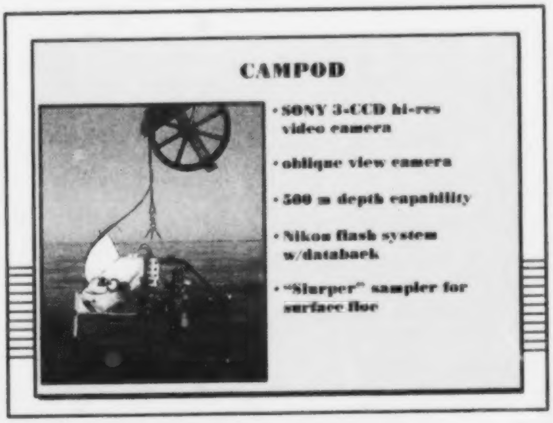
- Used ships of opportunity (supply & standby vessels), as well as DFO vessels
- Combined water column and benthic boundary layer sampling with near-bottom current data to estimate critical transport stresses
- Initiated field program at Cohasset and Panuke (Copan) and expanded study to Hibernia and SOEI (Sable)
- Developed a series of new samplers to concentrate on benthic boundary layer processes





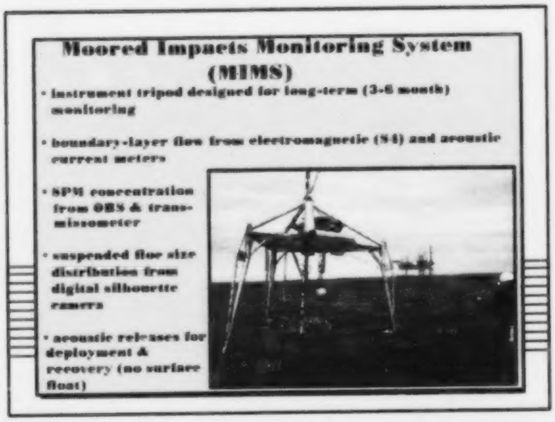
Benthic Organic Seston Sampler (BOSS)

- self-orienting into current
- delay timer on trigger
- samples water and SPM within 50 cm of seabed
- usually used in 24-hour "Anchor Stations"
- samples filtered on board for later analysis at B.I.O.



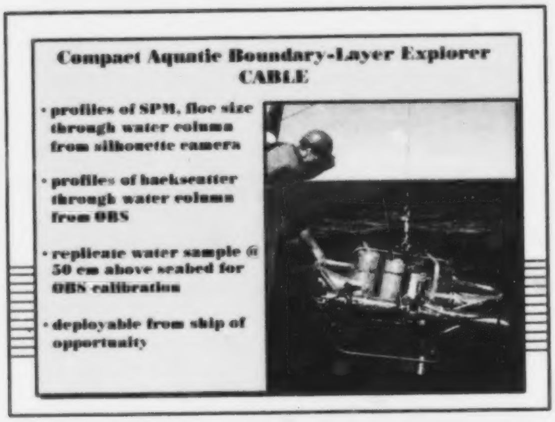
CAMPOD

- SONY 3-CCD hi-res video camera
- oblique view camera
- 500 m depth capability
- Nikon flash system w/databack
- "Slurper" sampler for surface floc



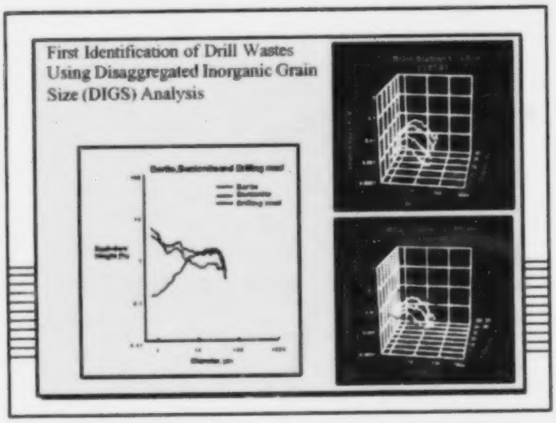
Moored Impacts Monitoring System (MIMS)

- instrument tripod designed for long-term (3-6 month) monitoring
- boundary-layer flow from electromagnetic (S4) and acoustic current meters
- SPM concentration from OBS & transmissometer
- suspended floc size distribution from digital silhouette camera
- acoustic releases for deployment & recovery (no surface float)

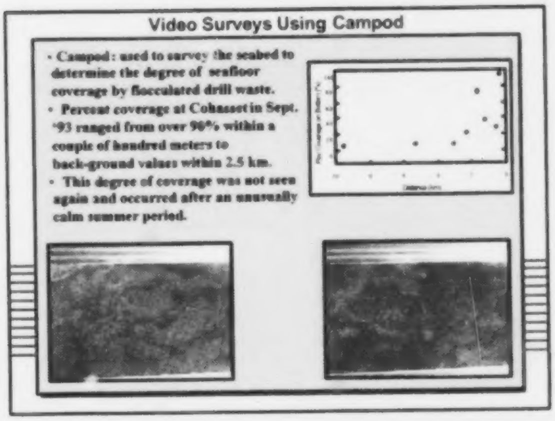


Compact Aquatic Boundary-Layer Explorer CABLE

- profiles of SPM, floc size through water column from silhouette camera
- profiles of backscatter through water column from OBS
- replicate water sample @ 50 cm above seabed for OBS calibration
- deployable from ship of opportunity

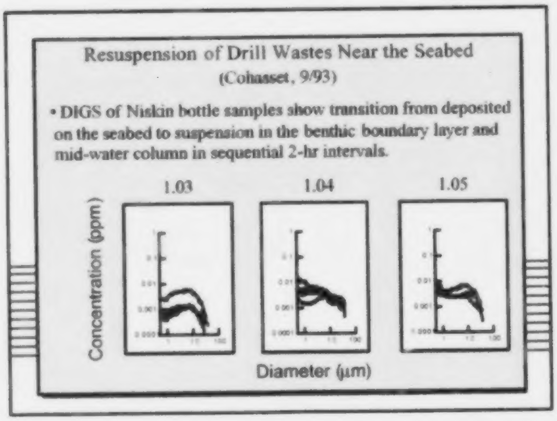


First Identification of Drill Wastes Using Disaggregated Inorganic Grain Size (DIGS) Analysis



Video Surveys Using Campod

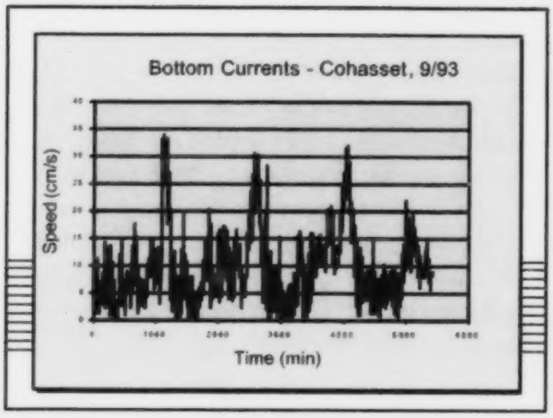
- Campod: used to survey the seabed to determine the degree of seafloor coverage by flocculated drill waste.
- Percent coverage at Cohasset in Sept. '93 ranged from over 90% within a couple of hundred meters to back-ground values within 2.5 km.
- This degree of coverage was not seen again and occurred after an unusually calm summer period.



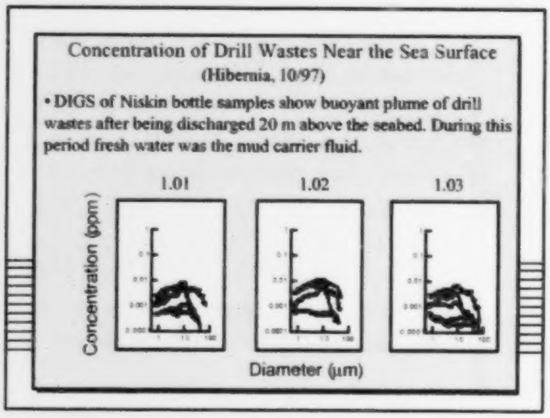
Resuspension of Drill Wastes Near the Seabed

(Cohasset, 9/93)

- DIGS of Niskin bottle samples show transition from deposited on the seabed to suspension in the benthic boundary layer and mid-water column in sequential 2-hr intervals.



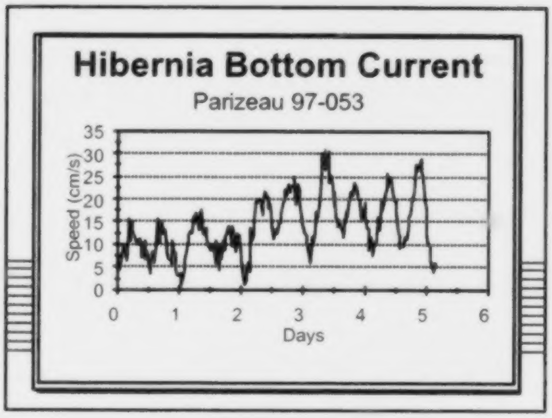
Bottom Currents - Cohasset, 9/93



Concentration of Drill Wastes Near the Sea Surface

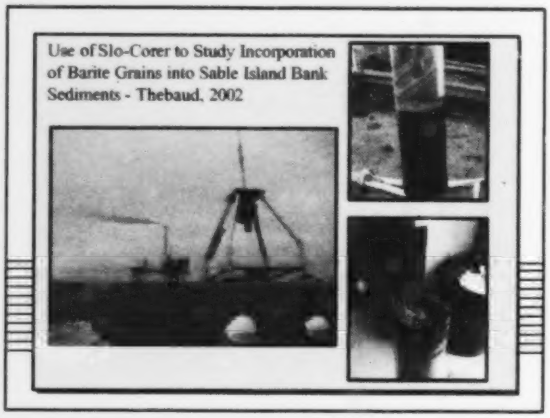
(Hibernia, 10/97)

- DIGS of Niskin bottle samples show buoyant plume of drill wastes after being discharged 20 m above the seabed. During this period fresh water was the mud carrier fluid.



Hibernia Bottom Current

Parizeau 97-053



Use of Slo-Corer to Study Incorporation of Barite Grains into Sable Island Bank Sediments - Thebaud, 2002

Field Studies of Drill Waste Dispersion on Sable Island Bank and the Grand Banks

Lessons Learned:

- DIGS analysis can be a useful tool for tracking drilling wastes on energetic offshore banks.
- Particulate drilling waste fines undergo deposition and erosion cycles which are complex but resuspend at current speeds below that necessary to resuspend the bed sediments (sands).
- Sable Island Bank and Hibernia have different hydrodynamic environments but both aredispersive.

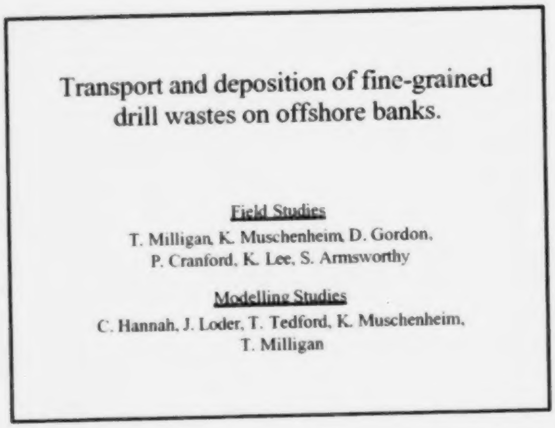
Discussion

When you look at characterisations of the hydrodynamic environment at different parts of the Sable Island Bank, they are more like each other, although they are some distance apart, than they are like Hibernia. Of course, a lot depends on depth. On the top of the Bank, where we have been working, mostly around the Cohasset and Panuke platforms, water depths are 38-40 m. The Thebaud platform is in about 38 m of water and has quite similar conditions. Once you start getting shallower (e.g., Venture in 20 m of water), it is even more dispersive yet comparable to some of the work done on Georges Bank where you have maximum bottom currents. Bottom currents there tend to reach as much as a knot, 45-50 cm/s. Sable Island is not so dispersive an environment as Georges Bank or the top of Georges Bank can be. One expects Hibernia to be much less dispersive but it was found to be more dispersive than the others.

Some bottom-mounted rigs operate at depths below 100 m. The final operating depth of MIMS (Moored Impact Monitoring System) is limited because the floats in the recovery system will be crushed. The cameras are limited to 250 m. There is a fair amount of useful technology that people might want to consider.

Transport and Deposition of Fine-grained Drill Wastes on Offshore Banks

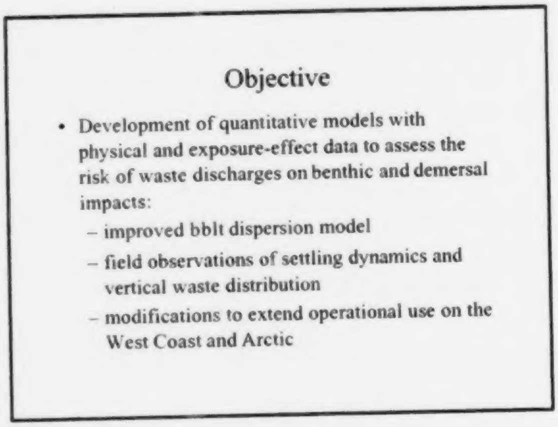
T. Milligan
Fisheries and Oceans Canada



Transport and deposition of fine-grained drill wastes on offshore banks.

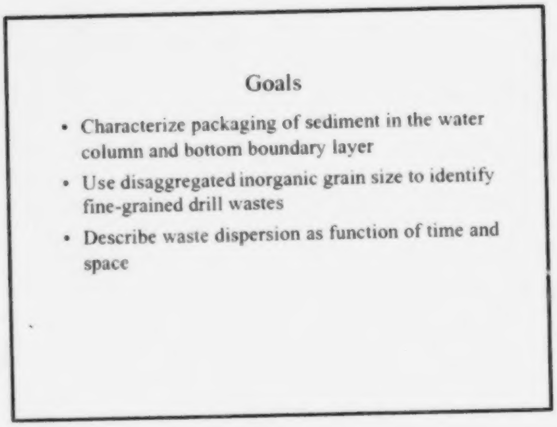
Field Studies
T. Milligan, K. Muschenheim, D. Gordon,
P. Cranford, K. Lee, S. Armsworthy

Modelling Studies
C. Hannah, J. Loder, T. Tedford, K. Muschenheim,
T. Milligan



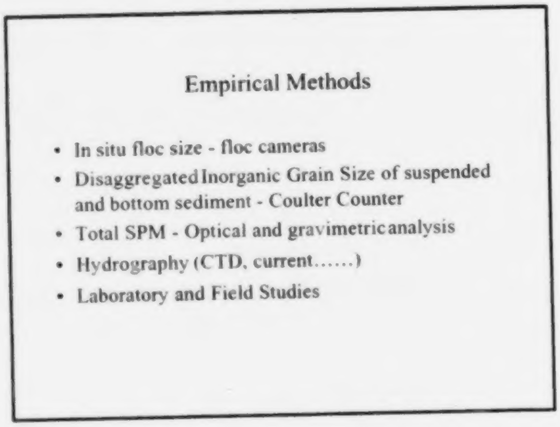
Objective

- Development of quantitative models with physical and exposure-effect data to assess the risk of waste discharges on benthic and demersal impacts:
  - improved bblt dispersion model
  - field observations of settling dynamics and vertical waste distribution
  - modifications to extend operational use on the West Coast and Arctic



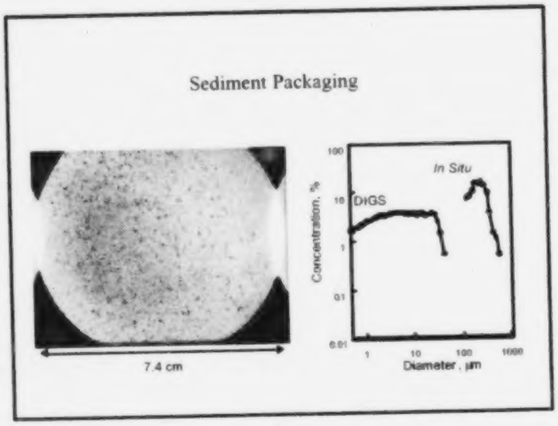
Goals

- Characterize packaging of sediment in the water column and bottom boundary layer
- Use disaggregated inorganic grain size to identify fine-grained drill wastes
- Describe waste dispersion as function of time and space

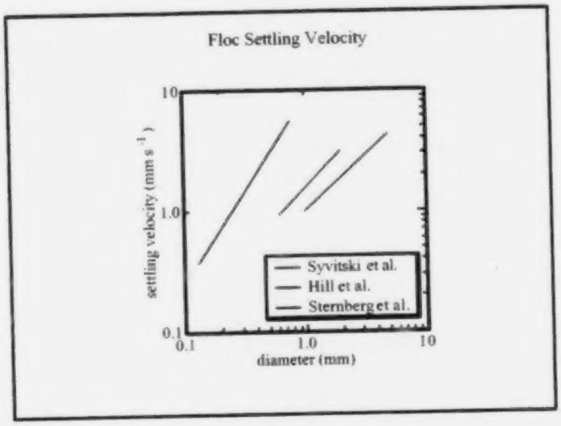


Empirical Methods

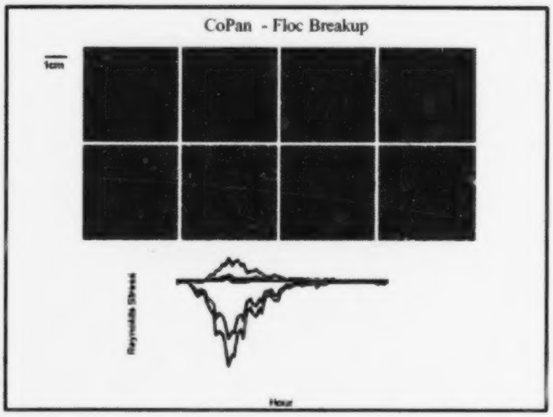
- In situ floc size - floc cameras
- Disaggregated Inorganic Grain Size of suspended and bottom sediment - Coulter Counter
- Total SPM - Optical and gravimetric analysis
- Hydrography (CTD, current......)
- Laboratory and Field Studies



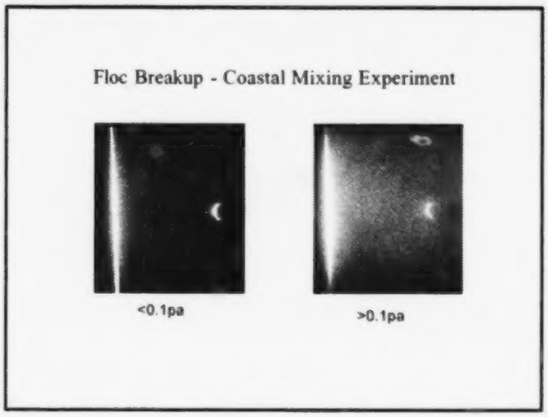
Sediment Packaging



Floc Settling Velocity

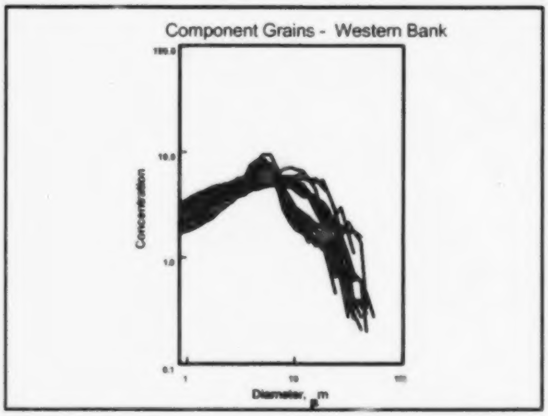


CoPan - Floc Breakup

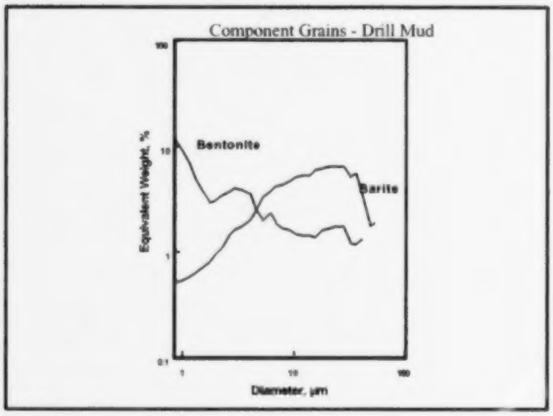


Floc Breakup - Coastal Mixing Experiment

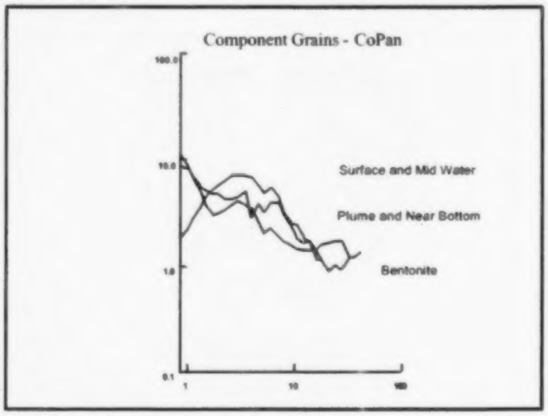
Component Grain Size



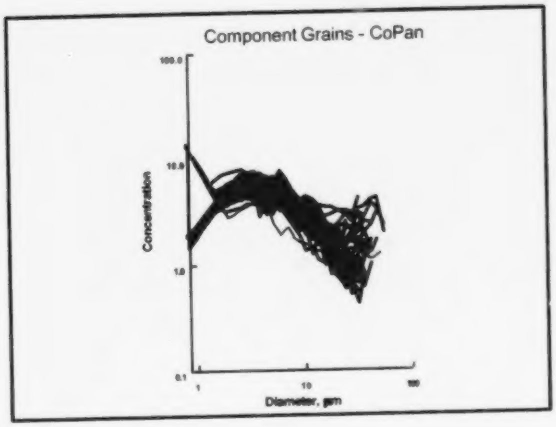
Component Grains - Western Bank



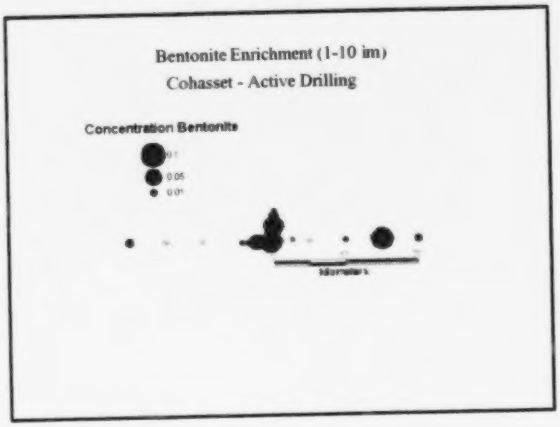
Component Grains - Drill Mud



Component Grains - CoPan

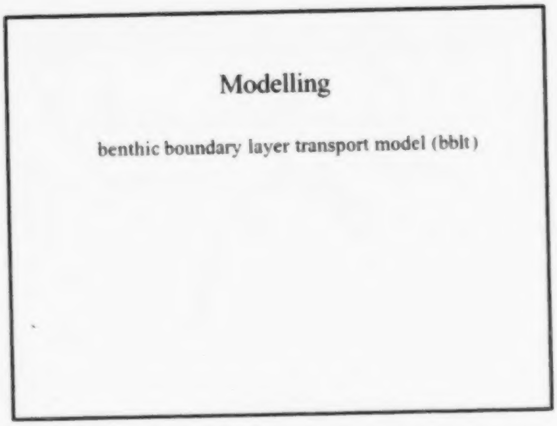


Component Grains - CoPan



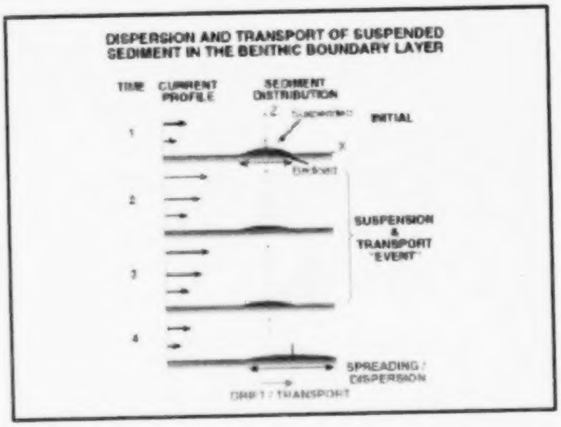
Bentonite Enrichment (1-10 im)

Cohasset - Active Drilling

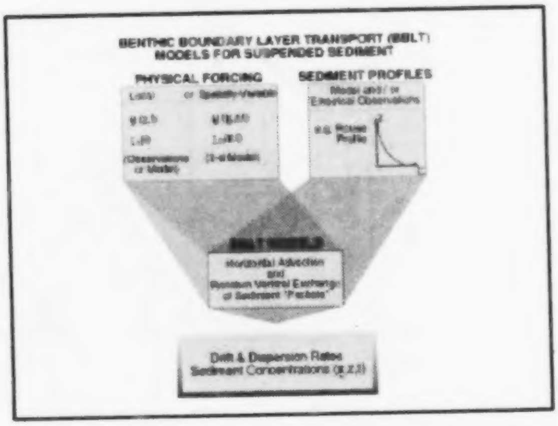


Modelling

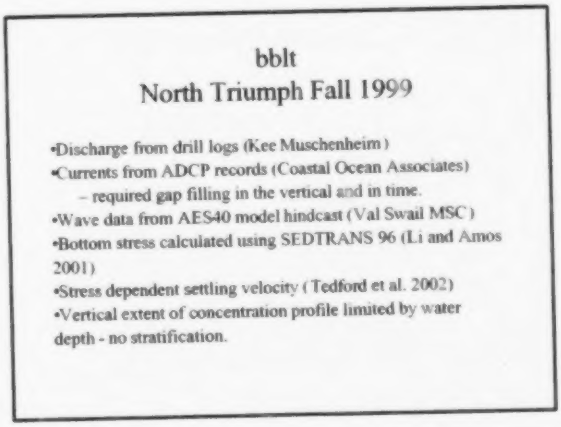
benthic boundary layer transport model (bblt)



DISPERSION AND TRANSPORT OF SUSPENDED SEDIMENT IN THE BENTHIC BOUNDARY LAYER

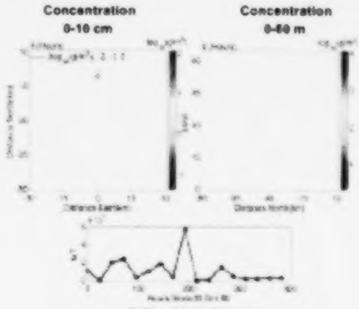


BENTHIC BOUNDARY LAYER TRANSPORT (BBLT) MODELS FOR SUSPENDED SEDIMENT

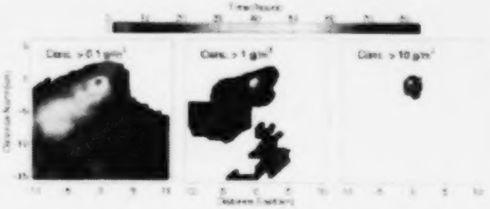


bblt
North Triumph Fall 1999

- Discharge from drill logs (Kee Muschenheim)
- Currents from ADCP records (Coastal Ocean Associates)
  - required gap filling in the vertical and in time.
- Wave data from AES40 model hindcast (Val Swail MSC)
- Bottom stress calculated using SEDTRANS 96 (Li and Amos 2001)
- Stress dependent settling velocity (Tedford et al. 2002)
- Vertical extent of concentration profile limited by water depth - no stratification.



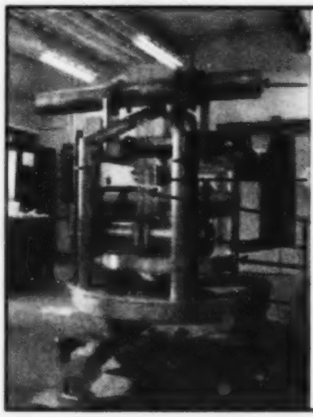
Drilling Waste Discharge



Integrated bottom concentration over time

Future Work

- Barite / Bentonite Partitioning
- Barite incorporation into sediments (Slow Corer)
- In situ settling velocity



INSSECT

(US Office Naval Research)

Digital Floc Camera

LISST

Tilt/Compass

Settling Column

Digital Video Camera

Carousel Sediment trap

Rotating Base

Future Work

- Barite / Bentonite Partitioning
- Barite incorporation into sediments (Slow Corer)
- In situ settling velocity (INSSECT)
- Spatially varying bblt
- Extend operational use to the West Coast and Arctic

Discussion

A typical bulk discharge in the water-based phase is 32 m^3. Over the course of the well, the amount of barite discharged is in the order of 40-100 m^3. Material can be disposed by drilling a well for reinjection or by shipping the material ashore. Oil-based muds can be recycled but they are sensitive. During the initial drilling there is normally some release.

Bentonite is the best tracer for looking at dispersion patterns around drill rigs. There can be material from previous activity so if you just drill down you can get an accumulated sample. It is difficult to validate the dispersion pattern if they are only dispersing for one or two days. We try to hindcast during the time they are on-site. There is no ability to validate the model at the present time; when you are there, you can only watch the stuff go by. One ESRF project is aimed at validation using the Environmental Effects Monitoring data that was collected to look at when discharges had been made versus when they had been out there doing their environmental effects monitoring measurements. They could not find a perfect match anywhere but the closest was at North Triumph – this was a new start-up so it was cleaner. We think there is a partition between barite and other material. Being granular, barite would be incorporated into the sediment so we could look at the barite discharge versus the pattern in the bottom sediment and see if it matches.

One of the things coming out of the population work suggests that if you do not want the material around the rig, you could mix it with a large amount of seawater to adjust the concentration, which would increase the dispersion. The BBLT model actually has a phase with a higher setting for the initial discharge of water-based muds that would have a very high aggregation rate and would produce a larger, faster sinking floc. After it gets on the bottom and is resuspended, it gets back to what we find is a more normal settling velocity for flocs on the bank. If you want to maximize the dispersion, you keep the settling velocity as low as you can and one way to do that is to prevent the material from flocculating.

There is anecdotal evidence that there are areas of the sea floor that accumulate material. There is a particular area at Cohasset that seems to have a lot of flocculated material in suspension. With some of the post development environmental monitoring and some of the work that is being done now at another site in the area, they are still finding material in suspension. We have not had samples to see if it is bentonite, but there does appear to be a lot of material in suspension. That could be a diatom floc that just happens to be there anyway and is concentrated. It is conceivable that there are areas, called "stress refuges", where flocs find an area where stress decreases and they accumulate there.

There are things in place now: water-based muds are considered non-toxic and the synthetics are shipped ashore once they have exhausted their drilling life.

Impact of Drilling Wastes on East Coast Scallop Stocks: Perception or Reality?

P. Cranford
Fisheries and Oceans Canada

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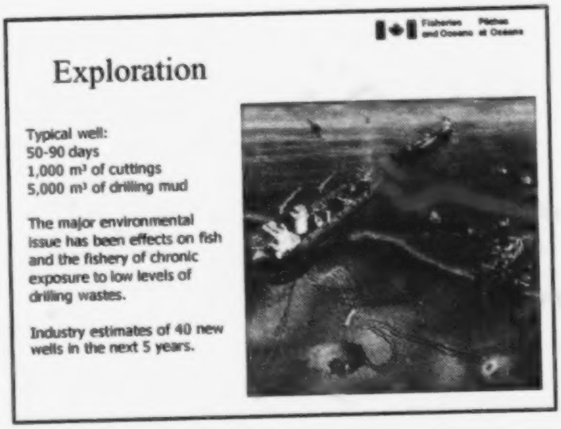
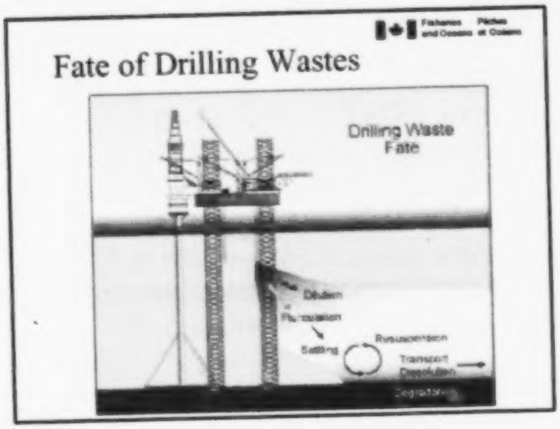


Exploration

Typical well:
50-90 days
1,000 m³ of cuttings
5,000 m³ of drilling mud

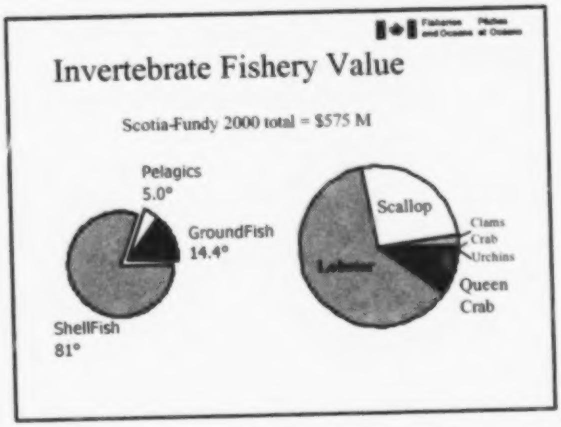
The major environmental issue has been effects on fish and the fishery of chronic exposure to low levels of drilling wastes.

Industry estimates of 40 new wells in the next 5 years.



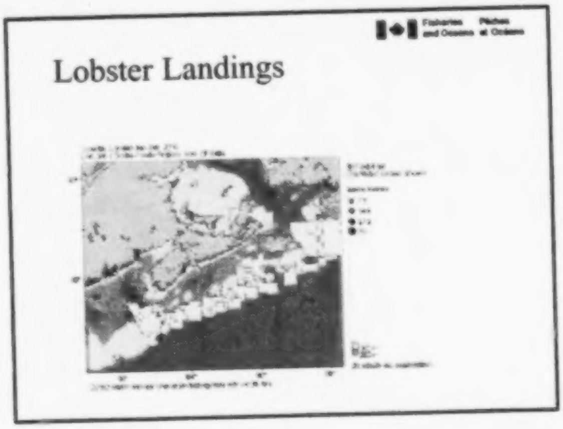
Fate of Drilling Wastes

Invertebrate Landings 2000



Invertebrate Fishery Value

Scotia-Fundy 2000 total = $575 M

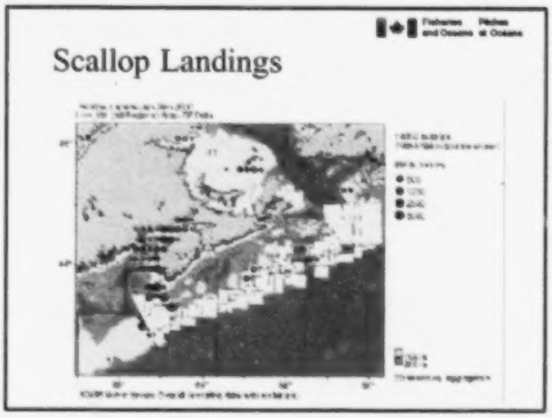


Lobster Landings

Snow Crab Landings

Surf Clam Landings

Quahaug Landings



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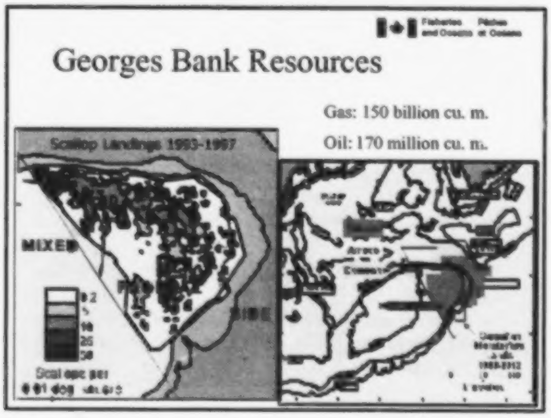
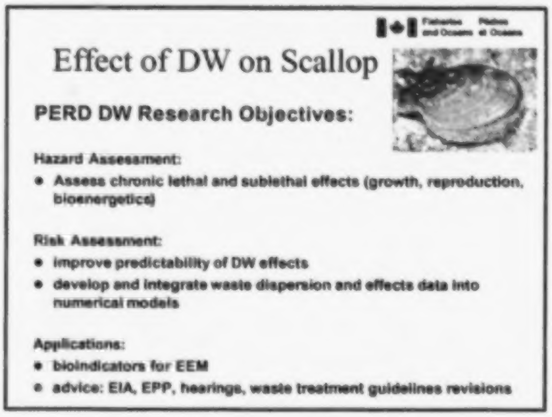


Georges Bank Resources

Gas: 150 billion cu. m.

Oil: 170 million cu. m.



Effect of DW on Scallop

PERD DW Research Objectives:

Hazard Assessment:

- **Assess chronic lethal and sublethal effects (growth, reproduction, bioenergetics)**

Risk Assessment:

- **improve predictability of DW effects**
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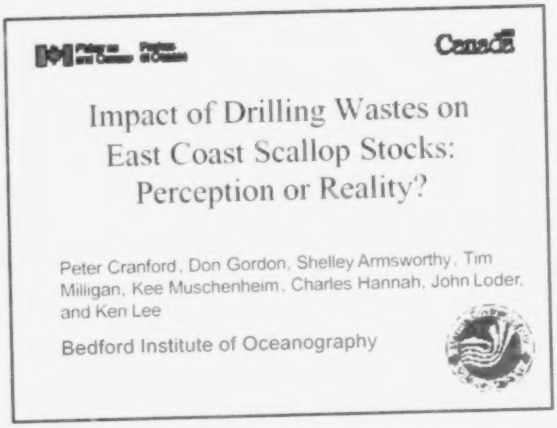

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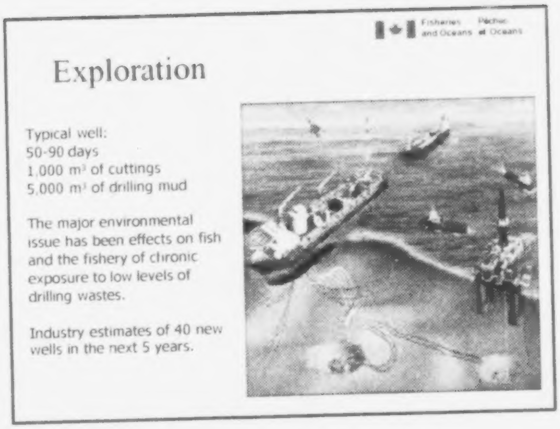

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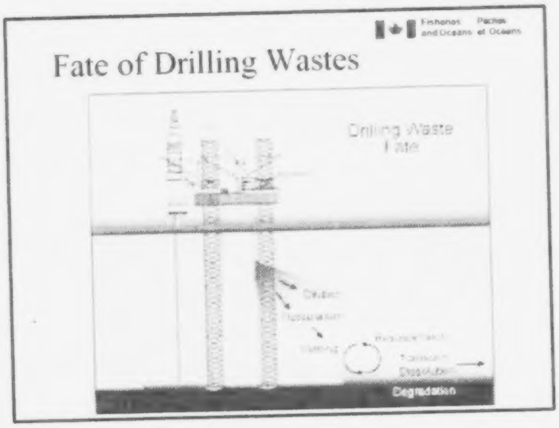

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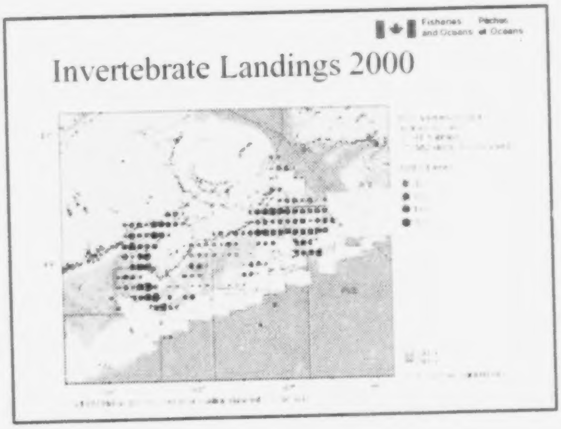

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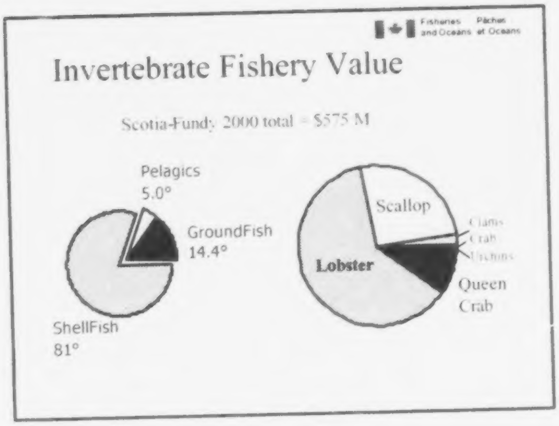

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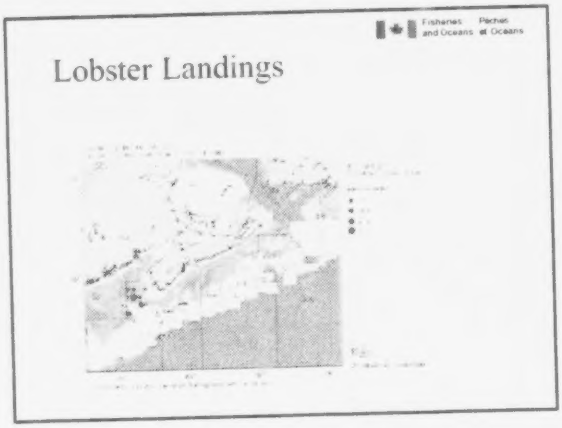

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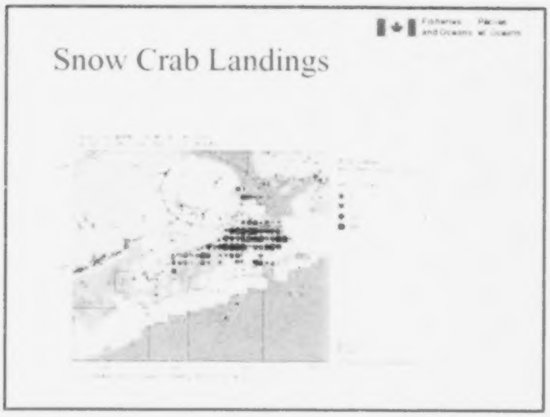

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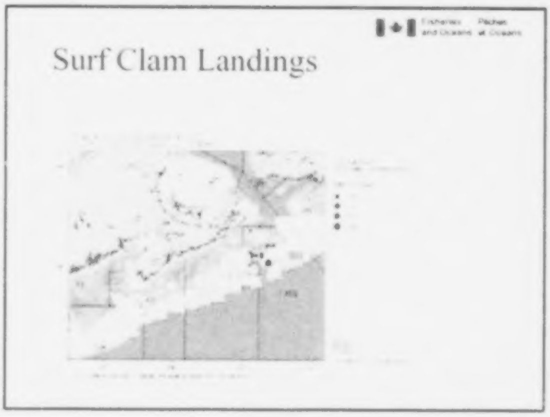
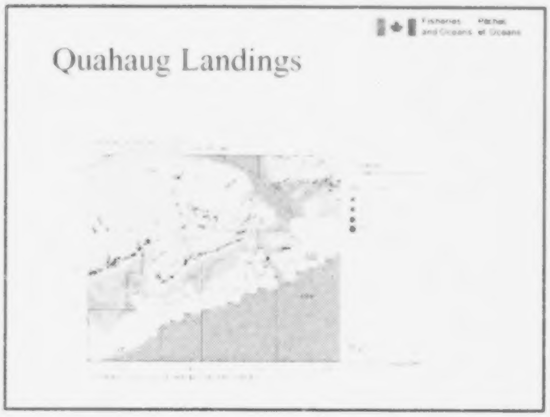
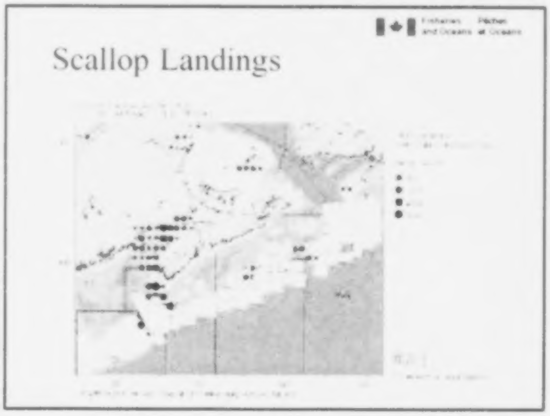


Surf Clam Landings



Quahaug Landings



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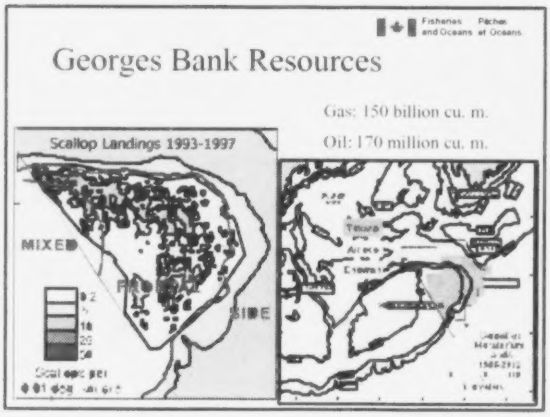

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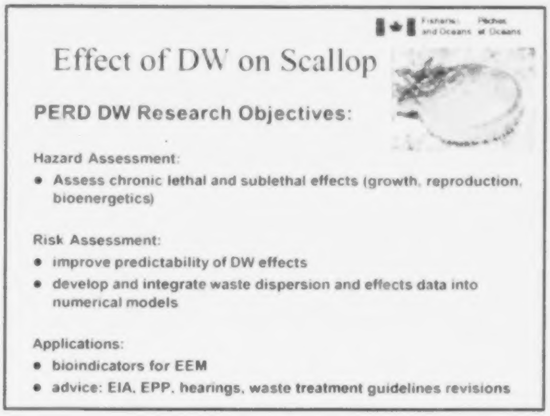

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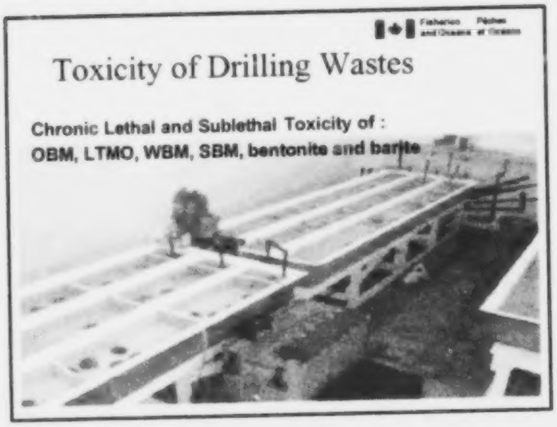

Toxicity of Drilling Wastes

Chronic Lethal and Sublethal Toxicity of :
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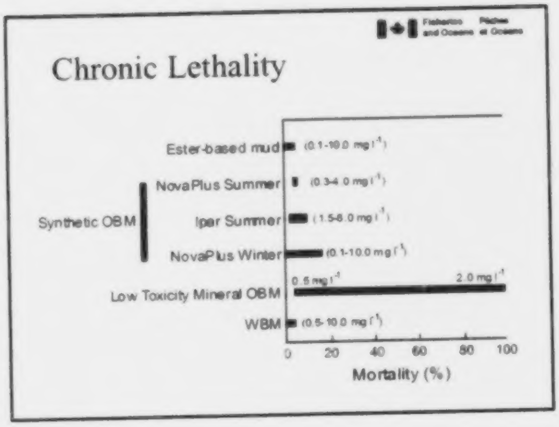
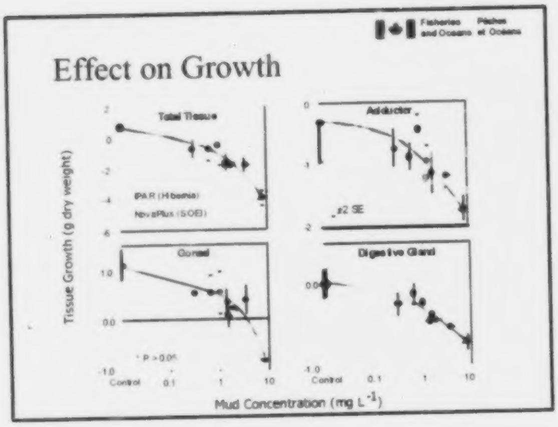
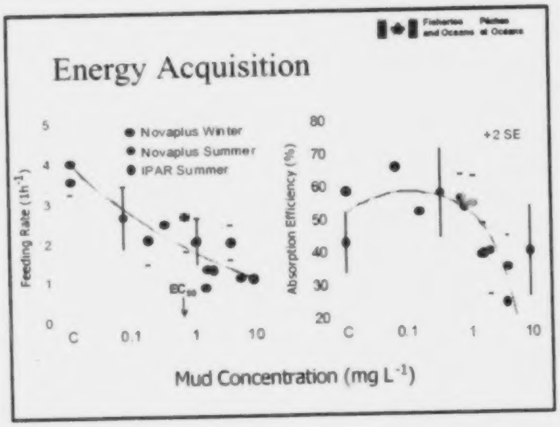


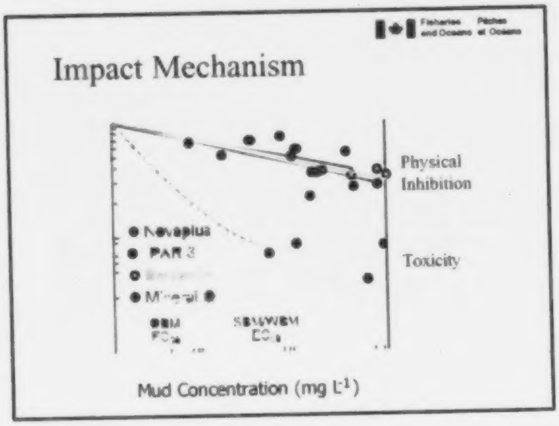
Chronic Lethality



Effect on Growth



Energy Acquisition



Impact Mechanism

Effects of Drilling Wastes

Environmental Concerns:

- **Smothering (cuttings - small footprint)**
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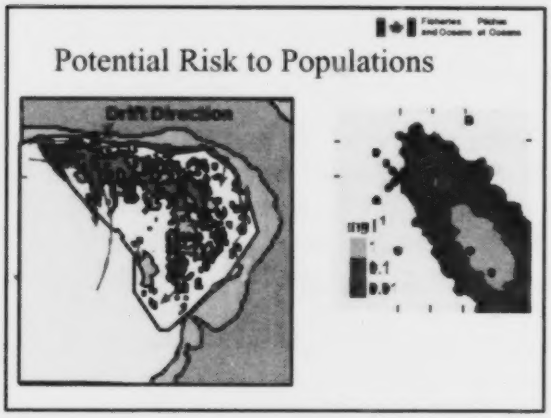
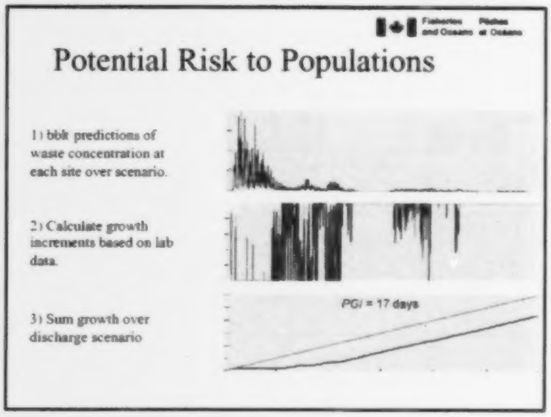


Potential Risk to Populations



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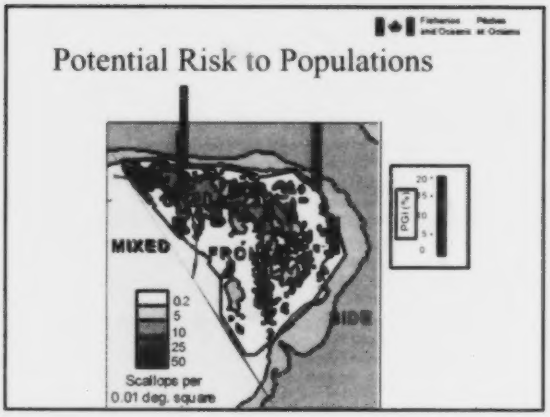

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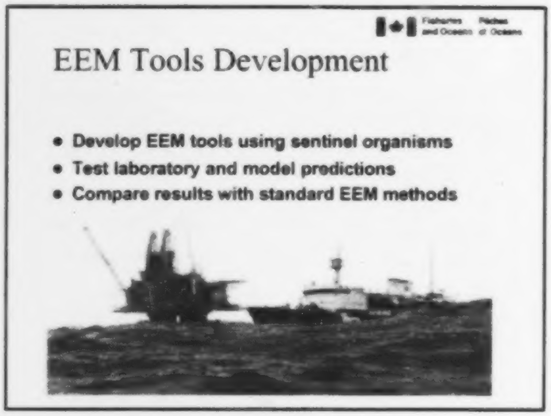

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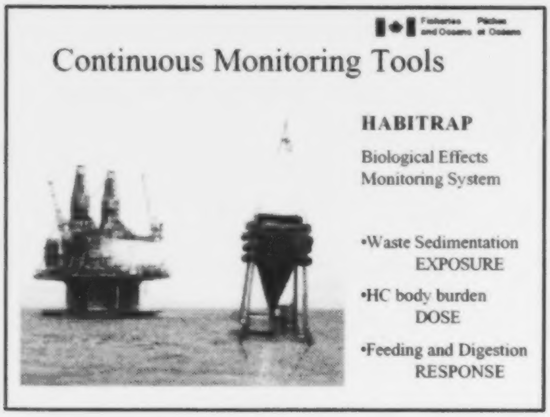


Continuous Monitoring Tools

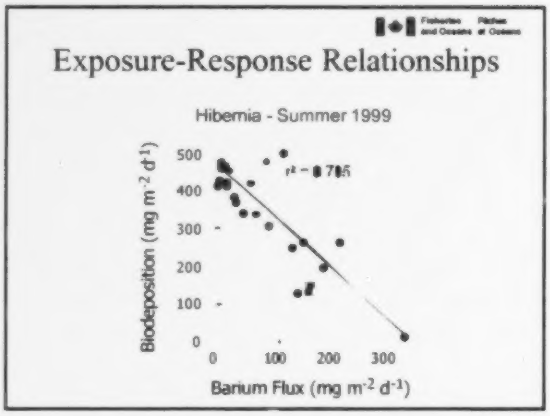
HABITRAP

Biological Effects Monitoring System

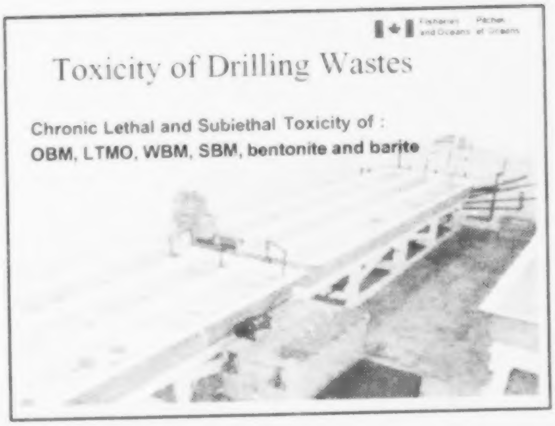
•Waste Sedimentation
EXPOSURE

•HC body burden
DOSE

•Feeding and Digestion
RESPONSE



Exposure-Response Relationships



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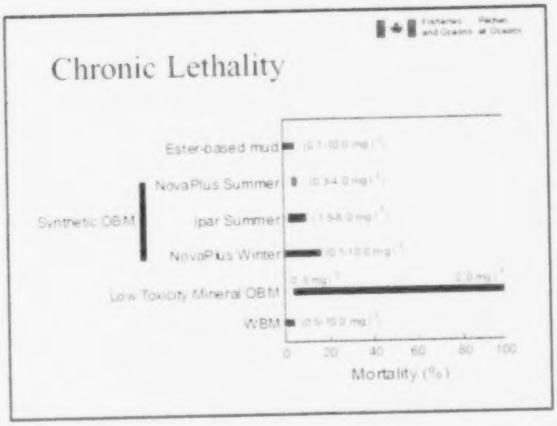

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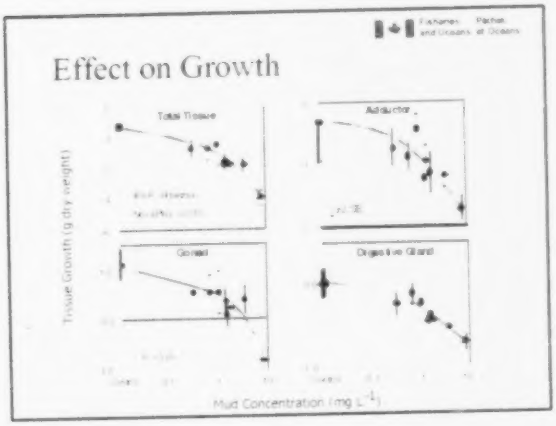

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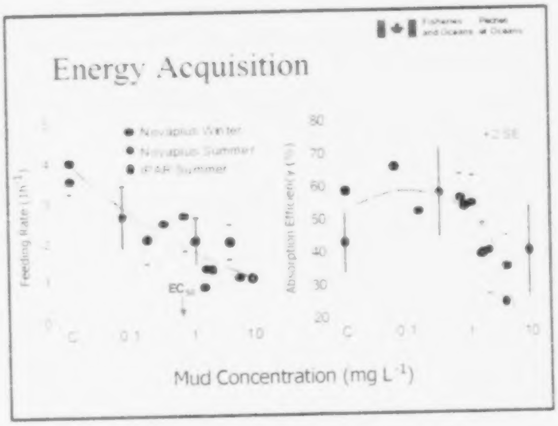

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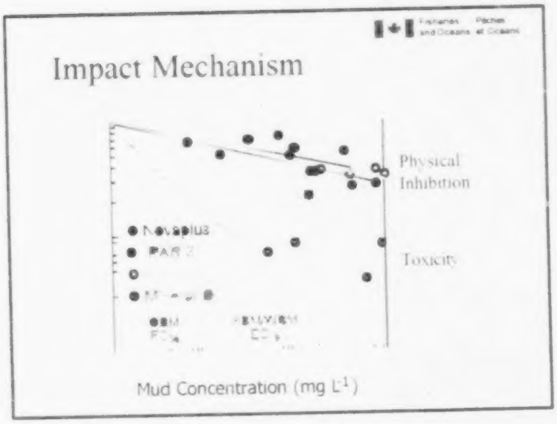

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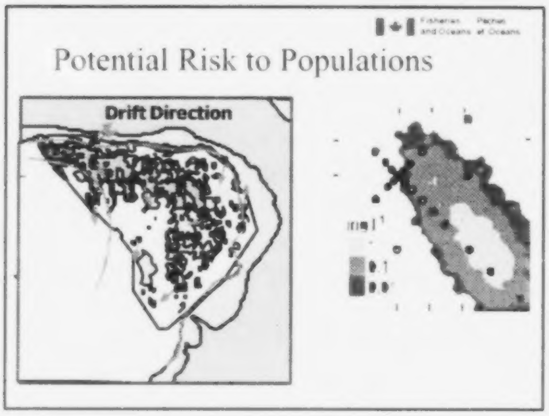

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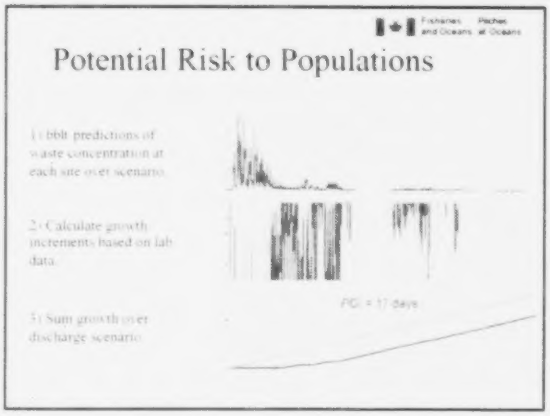

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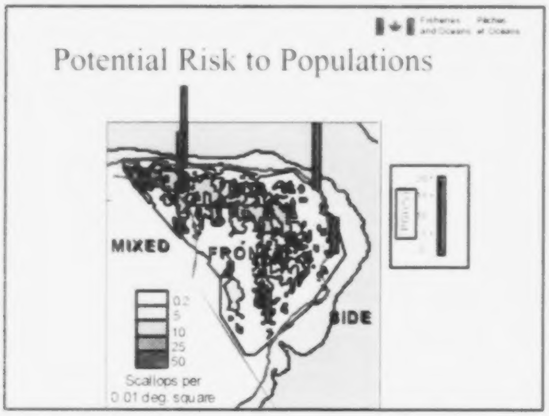

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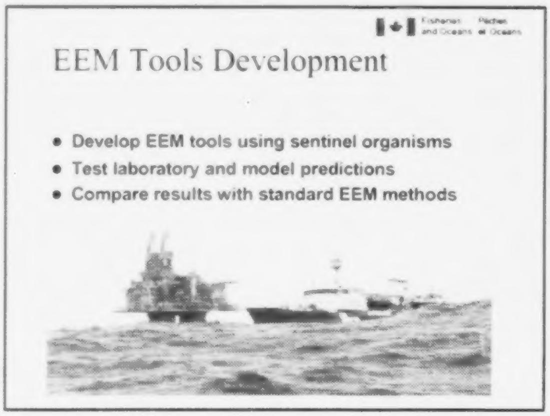

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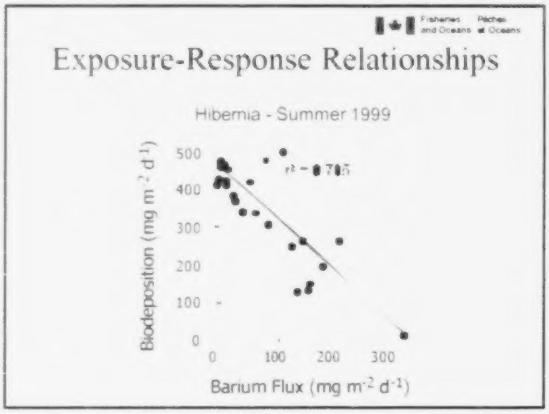
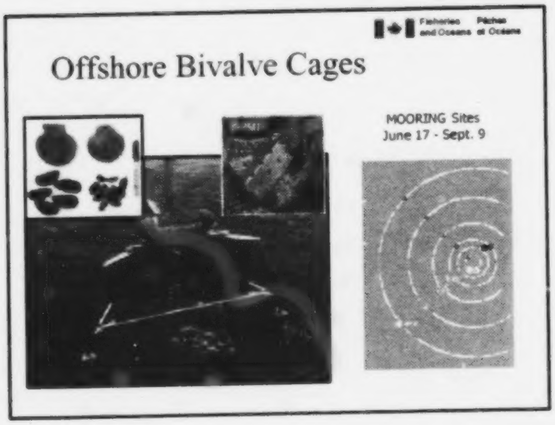


Exposure-Response Relationships

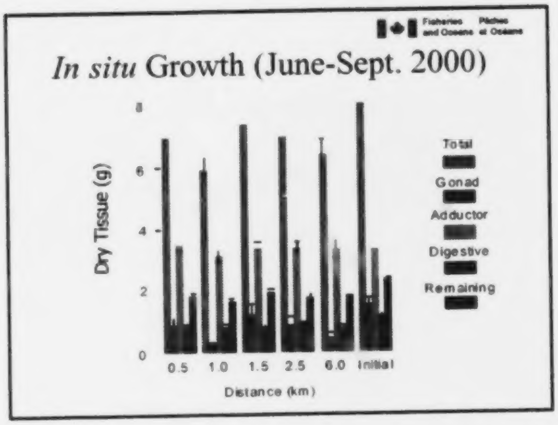
Hibernia - Summer 1999



Fisheries and Oceans Pêches et Océans

Offshore Bivalve Cages

MOORING Sites
June 17 - Sept. 9



Fisheries and Oceans Pêches et Océans

In situ Growth (June-Sept. 2000)

Fisheries and Oceans Pêches et Océans

Offshore Oil and Gas Environmental Effects Monitoring Workshop:

Approaches and Technologies

May 26th to May 30th, 2003

Bedford Institute of Oceanography
Dartmouth, Nova Scotia
Canada

www.offshoreeem.ca

Fisheries and Oceans Pêches et Océans

Perception to Reality: takes time

1988 - DFO review of *possible* impacts of GeorgesBank exploration
1988 - GeorgesBank moratorium implemented to 2000
1988 - (DFO) toxicity of OBM cuttings - zero growth/high mortality
1989 - (DFO/PERD) develop high energy exposure protocol
1990 - chronic effects of clay - high mortality/reduced feeding
1991 - chronic effects of clay - scope-for-growth, compensations
1992 - chronic effects of WBM cuttings (winter and summer)
1994 - chronic effects of OBM - high mortality at 0.5 mg l^{-1}
1996 - begin to integrate effects into fate models
1998 - zero discharge guideline implemented for OBM
1999 - chronic effects of SBMs - Hibernia and Sable
1999 - GeorgesBank Public Review Panel - major DFO science support
1999 - Hibernia caged bivalves - year 1
2000 - chronic effects of ester mud + Hibernia EEM technologies (year 2)
2001 - chronic effects of barite to scallops and other bivalves
2001 - OWTG review - increase allowable SBM on cuttings

Discussion

It is unlikely that a human could detect if a scallop has been taken from a plume. Taste-testing with scallops in oil in Newfoundland found that people preferred the oiled ones.

On the East Coast studies were targeted on scallops, which is the big fishery. On the West Coast (e.g., Hecate Strait), there are probably 200 fish species and maybe 2000 species of invertebrates. Scallops, the one species looked at, was considered the most sensitive. From the industry point of view, this is a worse-case scenario. Scallops are suspension feeders and other suspension feeders should be affected in the same way; sensitivity should not be so specific. We know that some species are not as sensitive as scallops but other species may be, there are a lot more that need to be looked at. The main interest is in chronic exposure. It is uncertain how applicable work on the East Coast is to the West Coast. There is a need to ramp up to a multi-species monitoring approach. Central species need to be identified and work started soon. The ramp-up costs are significant, requiring both technology and people.

In the study discussed, the various concentrations of sediment were being recycled. Unfiltered seawater comes into the tank constantly and drill mud is continuously being added. The dilution rate would give the desired concentration. The control population is only getting the unfiltered seawater that is coming in. The water is constantly flowing out as well so the concentration is constant. Part of the problem is that organisms are receiving particulates without food value. The clay actually interferes with the ciliary processes that control the feeding behaviour. Barite has an even greater effect than fine clay on the mechanism that allows them to feed. There are still questions about how that is actually happening.

There are metal data from sediments but not from the fishes themselves. The general knowledge about the metals in drill muds is that they are not bioavailable so they should not really have an effect on scallops. Quite a number of species have been looked at and they are just not accumulating much in the way of metals. We are dealing with cadmium (Cd) in scallops and oysters on the West Coast trying to understand some pathways. One pathway may be that particulates carrying Cd get into the gut and the Cd is released under acid conditions and becomes bioavailable. There are data indicating that scallops are good at picking up Cd and hanging on to it. Scallops are very strong bioacumulators of metals, particularly Cd and hydrocarbons. The types of metals we are looking at in drilling wastes are of a form that is not able to get into scallops. Most metals that accumulate in scallop tissue come from dissolved metals in the water as opposed to being ingested. Metals in drilling muds are not that type and cannot be assimilated. The metal would have to be accumulated into the tissue before it could be incorporated into the shell. The shell might be an indicator. There was a PERD proposal to study this but it was deemed a lower priority.

If there is a correlation between where scallops are and the area where sediments are most apt to accumulate, then sample location is critical. If a bug is selective in its location then the number could vary by a factor of ten from what you might think it is from a trap. The largest number of fish on Hibernia is close to the rig. Concerning scallop distribution, on Georges Bank, the place we see scallops is not in the sands but on the cobbly areas so it does not really apply. On the West Coast shrimp gather between sand depressions. Sand ridges are transient on Sable Island Bank where sand layers 15 cm deep move on each tidal cycle. A sediment trap might give an atypical sample depending where it is located. Hibernia was sampled but drill muds were not being discharged at the time that cages were out there. There is a lot yet to do to interpret these data so we do not want to jump to conclusions.

There are a number of rocky reef areas in Hecate Strait with lots of large boulders and epifauna. One of the main conclusions from our study is that the effect is going to be highly dependent on the site. The physical oceanography and the roughness define if there is going to be an effect or not. These define what the concentrations of drilling muds are going to be close to the seabed. The physics are really driving the biology. On Georges Bank, there were predictions ranging from very high effects to no effects in a small area so it really depends on the exact site you are dealing with.

PERD and Understanding Potential Effects of Oil Development: Grand Banks Experience

J. Payne

Fisheries and Oceans Canada

PERD AND UNDERSTANDING POTENTIAL EFFECTS OF OIL DEVELOPMENT: GRAND BANKS EXPERIENCE

J.F. Payne. Department of Fisheries and Oceans, St. John's, NL.

The content of a relatively large number of supporting slides is summarized.

Concern is currently being expressed about the potential effects of oil exploration and development in coastal waters of British Columbia. Development is proceeding in the meantime off the east coast on some of the world's richest fishing grounds such as the Grand Banks where the Terra Nova, Hibernia and White Rose fields are located. What will be the scale and nature of impacts of development whether it is occurring off Newfoundland and Nova Scotia or British Columbia? There is a substantial body of knowledge from field studies in the North Sea, the Gulf of Mexico, California, the Grand Banks and the Scotian Shelf (several studies discussed). There are companion laboratory studies including in areas funded by the Program on Energy Research and Development to gain more information of relevance with respect to drill cuttings, production waters and hydrocarbons in general (several publications discussed). These ongoing studies continue to be of immense value for provision of advice to Habitat Management on environmental impact statements (EIS) and providing industry with guidance in monitoring programs.

The majority of information available indicates that impacts will be minimal and pose little or no risk to fisheries and the environment. An exception is large oil spills in intertidal or shallow nearshore waters but these can stem from general shipping as well as activities related to oil development. However there remain knowledge gaps with respect to chronic toxicity (noted again recently by the National Research Council U.S.A.) that need to be addressed for reasons of scientific uncertainty or public assurance and PERD is presently providing some funds for this area of research. The "final" step in addressing uncertainty is to have rigorous monitoring programs that can provide early warning of potential problems. The Canada Newfoundland Offshore Petroleum Board is the regulatory authority for the Grand Banks and all three developments on the Grand Banks are carrying out programs which will provide early warning of any impacts on fish health, fish quality, sediment quality and primary productivity. In perspective, oil development in general is indicated to pose little risk to fisheries and the environment and residual concerns can reasonably be addressed through in-filling of knowledge gaps with respect to chronic toxicity and implementing monitoring programs of an early warning nature.

However, science is also revealing a potential for disconnect on the regulatory side vis a vis the habitat provisions of the Fisheries Act. For instance while the drilling of an exploratory well over a period of 60 days may involve the alteration or disruption of 500 cubic meters of sediment habitat around a rig site, one small boat dredging for clams may alter three to four thousand cubic meters of habitat per day. Other fishing related examples were also given. (This is not however to cast aspersions on fishing per se which common sense indicates would be difficult without impacting habitat to some degree.) Similar perspectives can be carried out on the relative importance of marine dusts produced by drilling on bivalves, corals etc. compared with dust produced by ongoing natural processes such as tides and storms or for instance the dust which might be produced "upstream" of a rig site by various fishing practices, episodic river runoff, etc. Also with respect to addressing cumulative impacts which is required by Environment Canada for EIS, broadscale non-industry related cumulative effect "add-ons" such as those indicated above presents rather challenging problems for industry or any other body for that matter from a scientific perspective. Altogether, these types of potential regulatory disconnects point to a need for ongoing dialogue between scientists and policy makers.

Care must also presently be taken with respect to knowledge gaps pertaining to the natural environment lest we raise perceptions of being unfocused. There is a difference in drawing up a list of knowledge gaps on what we don't know about the natural environment in broadscale terms of biology, geology and oceanography for an area, in comparison with what the standing science indicates to be reasonable knowledge gaps to address in relation to known scales of impact of exploration activities. This has been an issue of debate around PERD in the past and should be approached through all party participation with the standing science being reviewed firstly.

Although not covered by PERD to date, the potential effects of seismic has recently become the priority environmental issue on the east coast. One important aspect that needs to be addressed is the question of exposure distance relationships for producing sub-lethal damaging effects (serious pathologies, delayed mortality, reproductive effects, etc.) in representative organisms. There is virtually no information in this area (other than immediate effects on larvae) and needs to be addressed for reason of regulatory and public assurance. Our preliminary studies where we noted the production of abnormal posture in cunners, stunning of lobster, and blackening of codfish also support this need.

Discussion

Specific polycyclic aromatic hydrocarbons (PAHs) were not used. We have carried out chronic toxicity studies with fish exposed to sediments contaminated with petroleum hydrocarbons (e.g., Venezuela crude, Grand Banks crude) which are highly enriched in alkylated PAH, as well as studies with "combustion" source hydrocarbons (e.g., sediments from St John's Harbour), which are enriched in parental PAH. Single chronic toxic studies normally entail about two years of work in all. Our long-term studies generally point to more pathology in flounder exposed to petroleum source PAH than in fish exposed to combustion-source PAH. This is not to say that you would not find cancer, for instance, in fish exposed for a very long time to combustion-source PAH. Our experiments generally included a number of biochemical and pathological indices. The types of effects we are observing might be principally due to the more water soluble alkylated PAHs, such as alkylated naphthalenes.

The air gun used in the studies was small, about eight cubic inches, while guns may range up to 2000 cubic inches. Exposures were carried out at close range, about 1 m. It was anticipated that cod-fish larvae might be readily killed at this distance while adult animals (cod, cunner, lobster, etc.) would survive. While larvae were not killed, subtle effects that might be pathological in nature were observed in some species of adult animals. There is a need to investigate the potential for delayed mortality and morbidity in representative organisms exposed to seismic energy, with a view towards defining effects-distance relationships. Such studies are important for assurance. LGL is presently carrying out a study along these lines with snow crab in Newfoundland.

Production Issues: Produced Water and Oil Spill Remediation

Production Activity Concerns: Produced Water Discharges and Oil Spill Counter Measures

K. Lee

Fisheries and Oceans Canada

Fisheries and Oceans Pêches et Océans Canada

Production Issues: Produced Water and Oil Spill Remediation

K. Lee, C. Cobanli, P. Cranford, C. Hannah,
T. Milligan, K. Muschenheim, J. Payne,
K. Querbach, J.N. Smith, G.H. Tremblay,
A. Vezina, G. Wohlgeschaffen, P. Yeats,

Centre for Offshore Oil and Gas Environmental Research (COOGER)

Produced Water

- Waste water remaining after separation of oil and water
  - Two main sources
    - Formation water
    - Injection water
  - Condensate water

Produced Water

- Produced water is the largest volume waste stream from oil and gas production activities.
- Scientific research is needed:
  - to identify the potential impact of produced water discharges on the environment, if any.
  - to identify acceptable disposal limits for produced water to minimize the need and cost of produced water treatment and/or disposal by re-injection.

Produced Water: Environmental Transport, Fate and Effects

- Produced water contains a number of metal and organic constituents of environmental interest including:
  - hydrolysis metals
  - heavy metals
  - petroleum hydrocarbons
  - nutrients
  - radionuclides
  - treating chemicals

Produced Water:

- Emerging evidence suggests that production water discharges may impact biota (invertebrates, fish and larvae) to greater distances from operational platforms than originally envisaged.
- Some regulatory agencies and members of the environmental community are demanding zero discharge.

BBC NEWS

Friday, 22 March, 2002, 06:25 GMT

Oil waste 'harming cod'

Waste products from offshore oil exploration could be seriously harming cod in the North Sea, scientists in Norway say.

In experimental conditions, chemicals dissolved in waste water from oil platforms stunted the growth of the fish and affected their breeding patterns, the researchers found. It is not known how seriously cod are being affected in the wild. But the research will put pressure on oil companies to find other ways of disposing of the waste.

Produced Water:

- **An objective study on the impact of production water discharges in the Atlantic Region is required:**
  - **Studies to characterize produced water produced in the Atlantic Region**
  - **Dose response biological effect studies**
  - **Research on processes controlling the transport of contaminants associated with produced water discharges**
  - **Development of risk assessment models**

Produced Water: Environmental Transport, Fate and Effects

- **DFO study results to date:**
  - **Significant temporal variability in contaminant concentrations (metals and hydrocarbons).**
  - **Precipitation of hydrolysis metals may sequester contaminants for transport to the benthic boundary layer and the surface microlayer.**
  - **Toxicity of produced water is altered by chemical kinetics following its discharge.**

Offshore Waste Treatment Guidelines

- **(1996)**
  - **Total oil and grease content to 40mg/L (30 day rolling average)**
  - **24 hour maximum of 80mg/l**
  - **Disposal at lowest depth possible**
- **Current Revisions**
  - **Tolerance level reduced to 30mg/l (30 day rolling average) and 24 hour maximum of 60mg/l**

Produced Water - Metals (µg/L)

Metal	PW	Seawater*
Al	ND (80)-2100	1-10
Cd	ND (2)-6	0.04
Cr	ND (80)	0.2-2
Co	ND (2)-2	0.1
Cu	ND (8)-4200	0.3
Fe	12000-28000	1.5-4
Pb	ND (8)-45	0.02
Mn	1300-2300	
Ni	ND (20)-420	0.2
Zn	90-26000	1

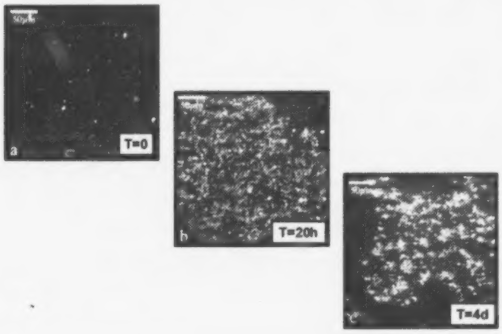
*Source: SOEP (1995)

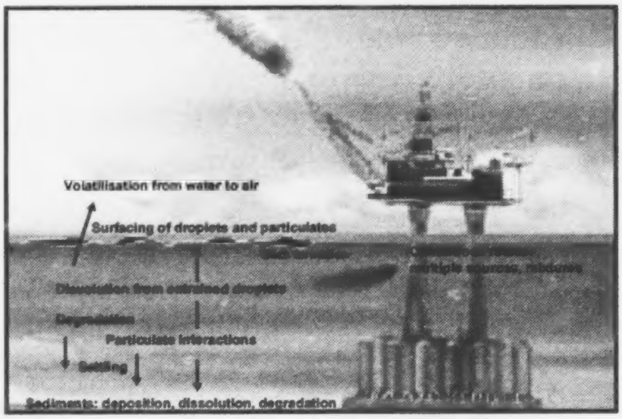
Produced Water - Naturally Occurring Radionuclide Material (NORM)

Sample	Collected	Ra-226		Ra-228		Pb-210	
		Bq/L	2σ error	Bq/L	2σ error	Bq/L soluble	Bq/L particulate
PW1	13-Aug-98	6.6	1.7	15.6	2.4	0.0002	0.0014
PW2	16-Sep-98	11.7	2.1	17.0	2.6		
PW3	1-Feb-99	8.7	1.6	15.0	2.3		
Ambient		0.001-0.002		0.001		0.0002-0.003	0-0.00008
Enrichment factor		~10,000		~20,000		none	~20

Produced Water - Nutrients

Sample	Collected	NH_4 (µM N)	PO_4 (µM P)	NO_2+NO_3 (µM N)
980501	01-May-98	1855	0.63	0.00
980502	02-May-98	1928	0.50	0.00
PW5	05-Aug-98	3041	3.83	0.18
PM2-2	13-Aug-98	2924	21.84	5.21
PW15	15-Aug-98	2828	3.29	0.25
981005A	05-Oct-98	4817	18.62	0.00
190708	25-Nov-98	5084	20.45	0.11




Volatilisation from water to air
Surfacing of droplets and particulates
Dissolution from entrained droplets
Degradation
Particulate interactions
Settling
Sediments: deposition, dissolution, degradation
multiple sources, residues

Sea Urchin and Microtox Tests

Sample	PM2-2	PW3	981005A	990412	990513
Collected	13-Aug-98	16-Sep-98	05-Oct-98	12-Apr-99	13-May-99
Salinity	90	89	89	87	88
Sea Urchin Assay (%)					
IC_{25}	13.5	4.1	5.9	15.2	>35.7
NOEC	3.4	1.12	1.12	11.4	11.4
LOEC	10.9	3.5	3.5	35.7	35.7
Microtox Assay (%)					
EC_{25}	39.8	>99	47.2	31.5	75.1

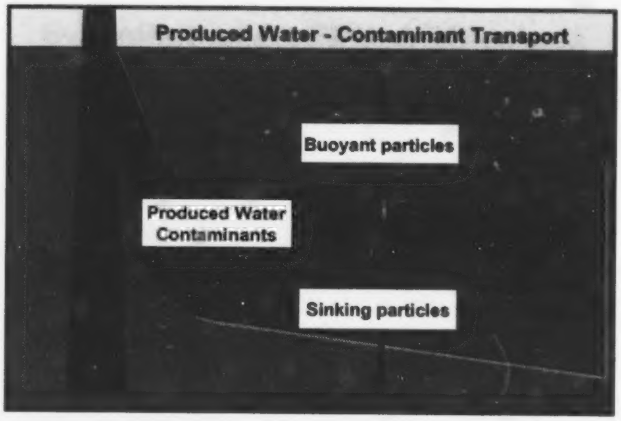
Microtox 100% test protocol

Sample	Collected	Salinity (ppm)	EC25 (%)
981005A	05-Oct-98	89	47.2
190707	19-Oct-98	88	1.8
990200	01-Feb-99	90	58.1
9902B00	08-Feb-99	90	67.8
990426	26-Apr-99	88	21.8
990513	13-May-99	88	75.1

Environmental Transport, Fate and Effects

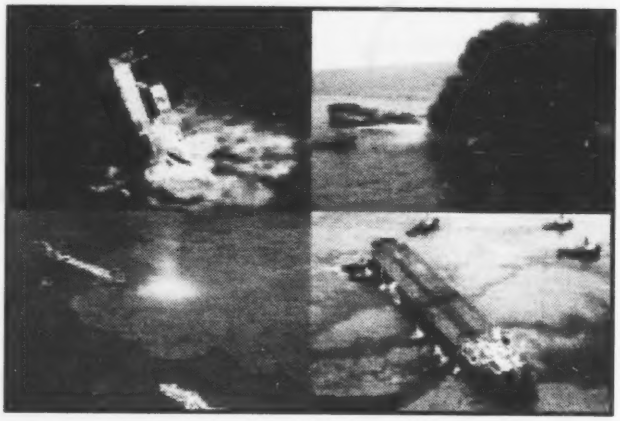
- Toxicity to early life stages of haddock, lobster and scallops has been determined
- Focus on chronic effects
- Biodegradation rates have been determined
- *An ecological risk assessment will be provided for use by resource managers to resolve a potential conflict that may obstruct offshore energy development*

Produced Water - Contaminant Transport



Accidental Oil Discharges and Spills

- Marine transport including sub-sea pipelines are the principal methods of transporting crude oil and its refined products to market within Canada.
- Public acceptance of the offshore industry is tempered by concerns over ecological damage from oil spills.



Remediation of Accidental Offshore Discharges and Spills

- PERD has been a primary supporter of Canada's research programs on oil spill impacts and countermeasures.
- Studies have been focused on Canadian issues (e.g., biodegradation studies on Hibernia/Terra Nova waxy crude oils and Condensate from the Scotian Shelf.
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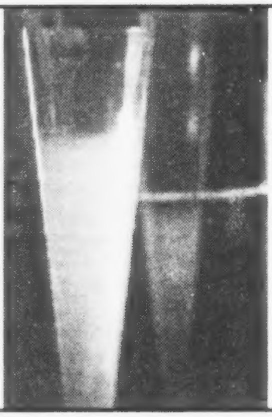

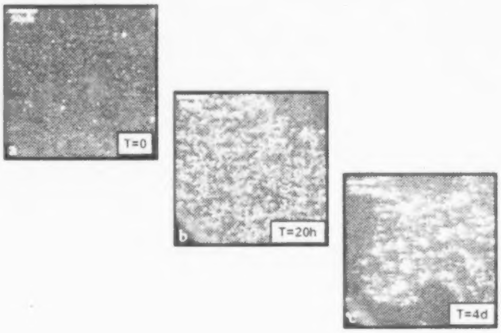

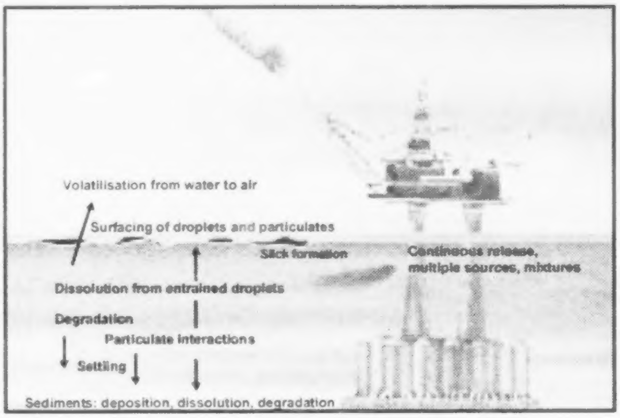

Volatilisation from water to air

Surfacing of droplets and particulates

Slick formation

Continuous release, multiple sources, mixtures

Dissolution from entrained droplets

Degradation

Particulate interactions

Settling

Sediments: deposition, dissolution, degradation

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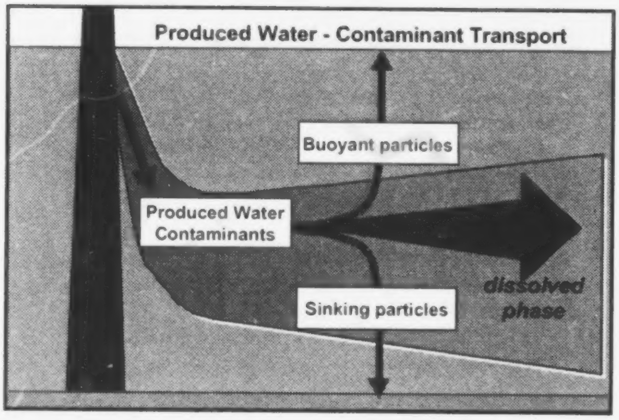

Produced Water - Contaminant Transport

Buoyant particles

Produced Water Contaminants

dissolved phase

Sinking particles

Accidental Oil Discharges and Spills

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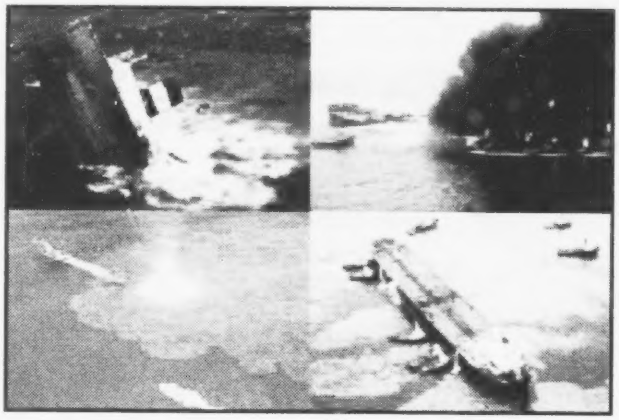

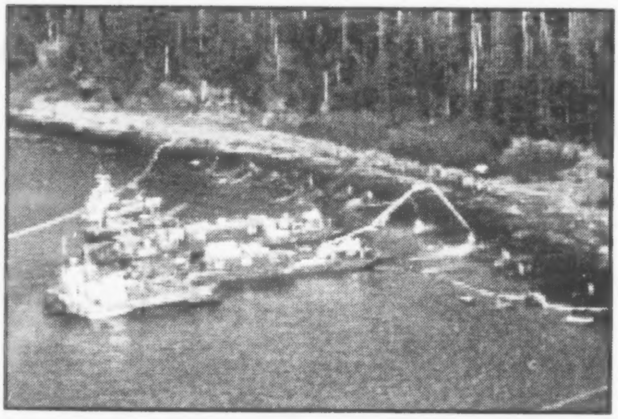

Remediation of Accidental Offshore Discharges and Spills

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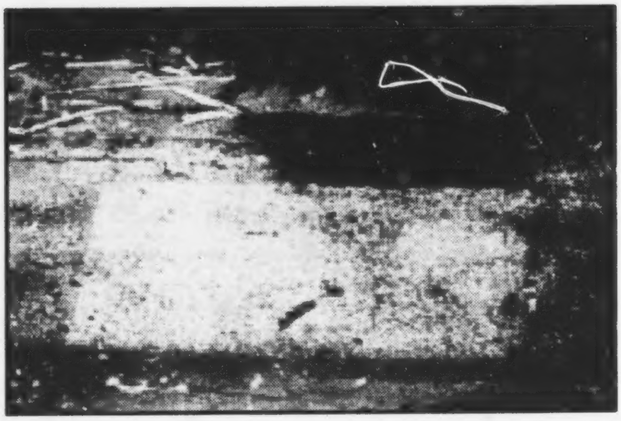
- Studies have been focused on Canadian issues (e.g., biodegradation studies on Hibernia/Terra Nova waxy crude oils and Condensate from the Scotian Shelf.
- Research programs maintain scientific expertise and laboratory facilities for use in emergency response operations.

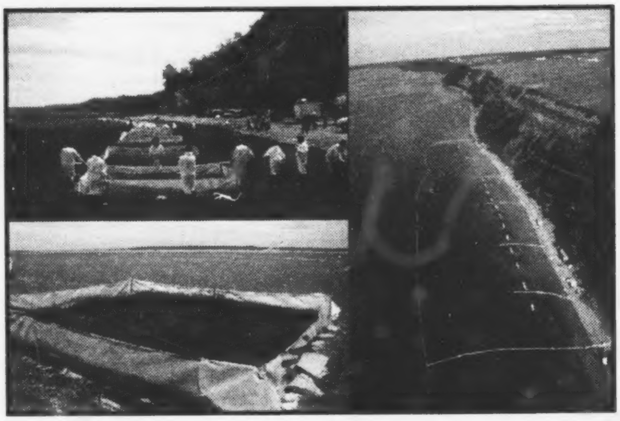
Marine Oil Spill Bioremediation

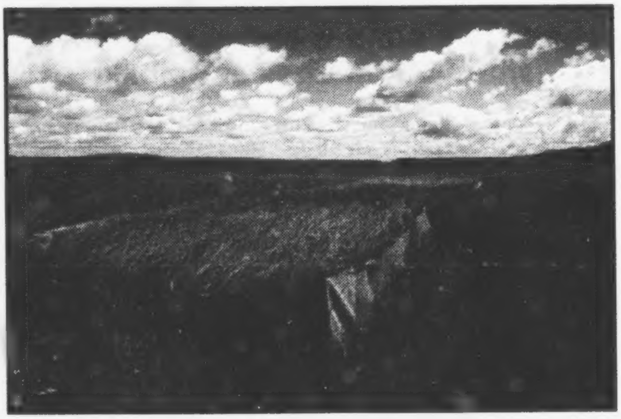
- DFO has been a world leader in the development and application of bioremediation strategies based on nutrient enrichment for oil spill clean-up on shorelines.
- This program has established bioremediation as an operational oil spill countermeasure for use on a world-wide scale (e.g., Operational Guidelines will be published by IMO in 2002).



Remediation of Oil-Contaminated Wetlands

- Wetlands provide nursery support for coastal fisheries, habitat for wildlife, and a protective mechanism for shoreline erosion.
- Traditional oil spill cleanup procedures may inflict more damage to wetland environments than the contamination itself.
- Hypothesized that enhanced growth of wetland plants by nutrient enrichment may accelerate oil degradation rates and habitat recovery.



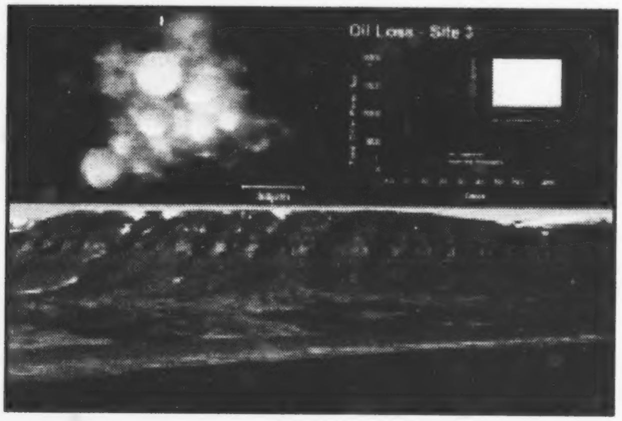


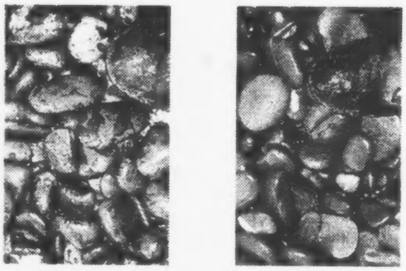
Remediation of Oil-Contaminated Wetlands

- DFO research has dispelled many of the erroneous perceptions that the public had of oil spills, their associated impacts and the government and industry's ability to respond.

Evaluation of Surf-Washing as an Oil Spill Response

- Development of an oil spill countermeasure for shoreline environments based on "surf washing" (accelerated dispersion of oil stranded within shoreline sediments into the water column by oil-mineral aggregate formation).
- Demonstrated on an operational scale following the Tampa Bay spill (USA), Sea Empress spill (UK), Erika (France), Desaguadero Pipeline (Bolivia).





Evaluation of Surf-Washing as an Oil Spill Response

- This *in situ* technique requires fewer resources, less logistical support, and generates little or no waste materials in comparison to the physical removal techniques currently used for oil spill clean-up.

Effects of Persistent Hydrocarbons and Acceptable End-point Indicators

- Studies to provide a standard test protocol series to define an operational level of acceptance following clean-up operations - resolving the question: "How clean is clean?"
- Data on the persistence and biological effects will be used in models to predict the ecological impact of oil spills.

Toxicity Identification and Evaluation (TIE) of Toxic Components in Residual Oil

- *Chronic exposure* to PAHs in residual oil may impair the development of fish embryos and reduce population fitness over multiple generations.
    - Data linking developmental effects to the alkyl–PAH "fingerprint" of crude oils will improve our ability to assess the ecological risks of oil spills in aquatic environments.
    - Provision of a cost effective and environmentally sound protocol for improved oil spill response strategy selection and resource damage assessments.

Assessment of Chemical Oil Dispersants

- To determine the fate and effects of chemically dispersed oil and its potential effects on biota over several trophic levels, including commercial species of interest
- Data for use in risk assessment models on chronic effects of low-level hydrocarbon exposure
    - Assessment of the net environmental effects of using chemical oil dispersants
    - Provision of scientific knowledge to refine the dispersant use guidelines/policy in Canada

Discussion

In most natural environments, you would not have to add clay particles to facilitate the formation of oil-mineral aggregates. There is ongoing work with the Coast Guard to look at adding clay to disperse oil spills on ice. By law, if you have an oil spill on ice the Coast Guard has to try to recover all the oil, so recovery of small amounts of oil could require removing tons of ice. In a project originally funded by PERD, we looked at the potential to disperse oil with clay and found it to be effective. The Coast Guard R&D Fund continues to support that work. A tanker going up the Saguenay Fjord punched a hole its side and leaked oil all the way up the fjord. After some consultation, the Coast Guard dispersed clay on the oil and mixed it using the icebreaker. They reported that the oil disappeared into the water.

The landed value of oil and gas in Nova Scotia now exceeds that of the fishery. There are impacts from offshore oil and gas activities. The question is: What are we going to accept?

Working Groups

Three breakout groups were identified according to the themes of the three POL groups represented at the workshop:

- POL 1.2.1, Offshore Environmental Factors
    Chair: P. Smith (DFO)
    Rapporteur: D. Masson (DFO)
- POL 1.2.3, Marine Transport and Safety
    Chair: R. Frederking (NRC)
    Rapporteur: V. Barrie (NRCan)
- POL 1.2.4, Offshore Environment Impacts
    Chair: K. Lee (DFO) and H. Bain (DFO)
    Rapporteur: B. Crawford (DFO)

The working groups were asked to:

- Develop a consensus on what research will be applicable to the West Coast, using past work and East Coast work as a starting point.
- Identify specific gaps in West Coast knowledge and propose activities that could build on existing work that could be supported by a) PERD or b) someone else. In cases where PERD would have a role to play, identify how these activities would best fit into the existing structure.
- Identify potential partnerships (governments, industry and universities). Identify alternate sources of funds.
- Identify generic national offshore oil and gas issues.
- Link needs to research timelines (i.e., exploratory activity focus).

Working Group on PERD POL 1.2.1 – Offshore Environmental Factors. Wind, Waves, and Currents

The working group first compiled a list of generic research areas it considered relevant to West Coast oil and gas development. It then proceeded carefully through the list, assigning the following parameters to each area:

- Detailed need for work
- How/where/by whom
- Urgency/timeline
- Resource requirements
- Potential collaborators
- Sources of leverage
- Ship time requirements

With respect to the timeline, the time at which the output of the research is required was referenced to the time of lifting of the moratorium (t=0). It was then assumed that exploration would commence at a point roughly two years after the lifting of the moratorium (t=2), and that production would commence roughly eight years later (t=10). The results of the working group's deliberations are detailed in the table below.

Discussion

The cost of ship time does not include getting to and returning from the site - this would double the time and cost for ship support.

Both Queen Charlotte Sound and Hecate Strait are included, as there are some historic measurements in these areas. The Working Group current measurements are based on three moorings for a full year recycled every six months for three years. Bottom currents are required to understand and model near bottom transport of material and surface currents are required to understand spill trajectories. Long-range CODAR was considered. Obtaining a vector current field with a 100-km range CODAR at two sites would cost about $400K. Instrumenting existing wavebuoys would provide real data from point sources and rigs could also be instrumented. Data would support emergency response. The need to evaluate these data would be a PERD concern.

The Benthic Boundary Layer Transport (BBLT) model is well developed and used in conjunction with circulation models to estimate transport in the bottom boundary layer. These models have common data requirements. There is an existing PERD project for BBLT and West Coast concerns are written into the fourth year of this project. Co-operation (i.e., data sharing) with GSC is important as there are common data requirements for boundary layer and transport models.

Project Parameters\Name	Design Criteria	Wave Data Analysis & Modelling	Wind Data Analysis & Mesoscale Modelling	Current Measurement & Modelling	BBL Transport
Detailed need for work	1) Analysis of existing data for the selection of drilling structures; 2) Detailed hindcast for design of production platform	1) collect and analyze 2-D wave data in exploration areas; 2) high-resolution wave model	Remote sensing analysis and fine scale models are required to understand mesoscale atmospheric variability for explosive cyclogenesis, extreme winds, waves and currents	1) collect winter measurements for model verification; 2) 3-D circulation model for a) hindcast => impact assessment b) forecast => emergency response	means for estimating transport and dispersion in the benthic boundary layer => impact assessment
How/where/by whom	EC – MSC – Downsview Pac. Weather Cen.	DFO – IOS	DFO – IOS EC – MSC	DFO – IOS	DFO – IOS/BIO
Urgency/timeline	1) at lift of moratorium; 2) 5 yr. post-moratorium	1) 2 yrs prior to moratorium lift; 2) 2 yrs prior to moratorium lift	at lift or later	at lift	at lift + 1 yr
Resource requirements	1) $25K/yr for 2 yrs; 2) $200K/yr for 3 yrs	$150K/yr for 4 yrs.	$150K/yr for 4 yrs	$250K/yr for 3 yrs	$25 K/yr for 2 yrs
Potential collaborators	DFO – IOS	DFO – BIO EC – MSC	DFO – BIO, UBC CCRS	DFO – BIO	GSC
Sources of leverage	OGP US Army	DFO – IOS MSC	CCAF CFCAS	Industry	ESRF OEI POL
Ship time requirements	None	4 days incremental for 4 yrs	None	28 days/yr for 3 yrs	none

Working Group on PERD 1.2.3 – Marine Transportation and Safety (plus Seismic, Geoscience).

Review	Timeline for outputs	Knowledge Review	Sensitive Habitats	Earthquake and Tsunami	Seabed Hazards	Foundation Conditions	Hydrocarbon Risk	MTS
Lifting of Moratorium	1.5 yrs	Yes	No	Yes	Yes	yes	Yes	Yes
Exploration seismic 2D and 3D and drilling	5 yrs		N (0-5)	N (0-5)	N (0-5)	N	N (0-5)	N (0-5)
Production	10 yrs	First requirement prior to all other requirements	Integrated cross-departmental knowledge base to identify sensitive habitats and conditions of restriction.	Enhance earthquake monitoring network to achieve the necessary specific outcomes.	To identify and map marine geohazards and identifying processes impacting development.	N (0-5) Geological framework for siting offshore structures and facilities.	N (0-5) Assess the risk involved in finding HC's, predict the types present in different areas and provide the background for environmental studies.	N (0-5) West marine traffic (barge, log booms) and environment is somewhat different than East Coast operating areas.
Project Cost (PERD)		300K	300K/yr	Yr 1 – 330K Yr 2 – 410K Yr 3 – 190K Yr 4 – 190K	400K/yr	300K/yr	200K/yr	50-100K/yr
Total Cost to all participants		1,000K	900k/yr	Yr 1 – 1,000K Yr 2 – 1,000K Yr 3 – 630K Yr 4 – 630K	1,000K	900K/yr	600K/yr	200K
Ship time			Yes		Yes			

Working Group on PERD 1.2.3, continued.

- Under Lifting of Moratorium, "No" indicates not enough is known at this time.
- NSERC funds can be utilised for ship time if part of an approved NSERC budget.
- Some of the areas considered under "sensitive habitat" are the same as those considered by other POLs. There will be a need for POL leaders to formulate proposals jointly.
- The present PERD budget for work of this type is about $700K.
- PERD would not provide or seek funding for West Coast offshore oil and gas concerns if the moratorium is not lifted as it would be hard to justify. Also, there are competing demands from the St. Lawrence and the North.
- If only exploration was being considered, the needs would be the same but the annual level of funding could decrease and the work could be done over a longer time period.
- There may be additional issues concerning pipelines that are not considered here.
- There is a need to include traditional values that will involve consultation with aboriginal groups hence the amount of time required to address issues may be longer than indicated here.
- The amount of time required from the beginning of a project until product moves to market will vary. Gas cannot be moved until it is sold thus requires more time than oil alone.
- There is a lot of barge traffic on the West Coast. This raises concern about the effect of towlines dragging on the sea floor in areas where pipelines exist.

Working Group on PERD POL 1.2.4 – Offshore Environmental Impacts.

Needs

- Risk assessment based on ecosystem approach to determine cumulative effects.
- Identify sensitive and unique marine areas to hydrocarbon exploration activities:
  - Effects of seismics on biota.
  - Effects of drill rigs on animal behaviour.
  - Identify critical areas for production of marine biota (feeding, reproduction, habitat).
  - Identify habitat of unique and rare biota (e.g., siliceous sponge reefs).
  - Identify regional transport processes (e.g., model deposition and transport of particulate drill wastes and other contaminants of concern) and take relevant measurements.
- Identify metal and hydrocarbon background levels, including oil seeps, river inputs, tar balls and hot water and gas vents.
- Risk assessment based on ecosystem approach to determine cumulative effects.
- Develop quantitative methodologies and population thresholds required for an ecosystem approach.

Discussion

Identification of metal and hydrocarbon background levels was done on the East Coast before development, although the effort was upgraded during the development phase. The task includes developing generic protocols for use across Canada. The Queen Charlotte Islands have numerous oil seeps suggesting that baseline work may be more critical on the West Coast. There is potential for high background levels on the East Coast as well, for example in the Cape Breton, Gaspé Bay Reserves and in the Quebec region.

While the topics presented are top priority, it is recognised that other important issues exist as well. These could have been brought out given more time for the Working Group to consider these issues.

The first two areas, risk assessment and the identification of sensitive and unique marine areas, have not been completed on the East Coast. This underlines the need to start work in these areas as soon as possible. Some background levels should be done before operations commence. It is important to delineate sensitive areas where industrial activity is not considered advisable so that industry can focus their effort in the appropriate areas.

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